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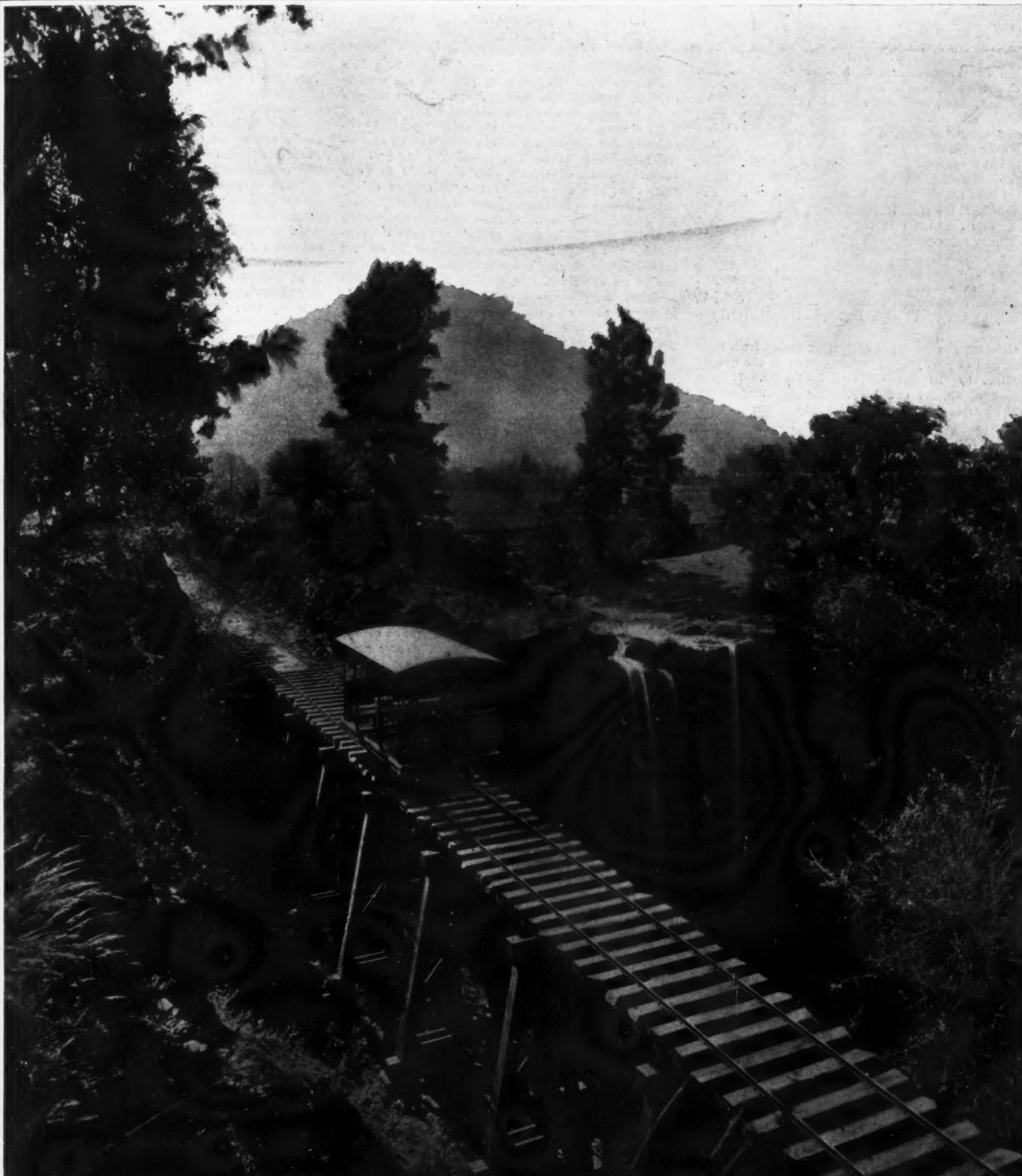


A PIONEER TRIP DOWN A NARROW-GAGE MEXICAN FOREST RAILROAD

AMERICAN FOREST RAILWAYS.—[SEE PAGE 56].

What Electrochemistry is Accomplishing—I*

Modern Methods and their Results

By Joseph W. Richards

My theme is to depict for you, as clearly as I may be able, the part which electrochemistry is playing in modern industrial processes. I have no exhaustive catalogue of electrochemical processes to present, nor columns of statistics of these industries; but my object will be to classify the various activities of electrochemists and to analyze the scope of the electrochemical industries. And since electrochemical industries have developed in almost all parts of the world except Pittsburg, I will endeavor to bring to your view by means of pictures, taken from actual photographs of plants in operation, the reality of the large and important electrochemical industries.

SCOPE OF ELECTROCHEMISTRY AND ELECTROMETALLURGY.

Chemistry is the science which investigates the composition of substances, and studies changes of composition and reactions of substances upon each other. As an applied science, it deals chiefly with the working over of crude natural material, and its conversion into more valuable and more useful substances.

Some common examples, to illustrate this statement, are the conversion of native sulphur into sulphuric acid, the manufacture of soda and hydrochloric acid from common salt, the conversion of phosphate rock into super-phosphate fertilizer, etc., etc. Several pages would not suffice to merely catalogue the great variety of chemical industries; immense amounts of capital are invested in them, and they are some of the most fundamental industries in their relation to supplying the needs of a rapidly advancing civilization.

Metallurgy is the art of extracting metals from their ores, and of purifying or refining them to the quality required by the metal-working industries. It is a branch of applied chemistry. The metallurgical industries form a highly important part of our national resources; on them we depend for iron, steel, copper, brass, gold, silver, lead, zinc, aluminium, etc., in fact for all the supply of metals used in arts and industry.

Electrochemistry is the art of applying electrical energy to facilitating the work of the chemist. It is chemistry helped by electricity. It is the use of a new agency in accomplishing chemical operations, and it has not only succeeded in facilitating many of the most difficult and costly of chemical reactions, but it has in many cases supplanted them by quick, simple and direct methods; it has even, in many cases, developed new reactions and produced new materials which are not otherwise capable of being made. A few examples will illustrate these points: Caustic soda and bleaching powder are made from common salt by a series of operations, but the electrical method does this neatly and cheaply in practically one operation; lime and carbon do not react by ordinary chemical processes, but in the electric furnace they react at once to form the valuable and familiar calcium carbide; carbon stays carbon except when the intense heat of the electric furnace converts it into artificial graphite. The list of such operations is a long one, and it may be said that the chemist has become a much more highly efficient and accomplished chemist since he became an electrochemist, and he is becoming more of an electrochemist daily.

Electrometallurgy applies electric energy to facilitating the solution of the problems confronting the metallurgist. Its birth is but recent, yet it has rendered invaluable service; it has made easy some of the most difficult extractions, has produced several of the metals at a small fraction of their former cost, and has put at our disposal in commercial quantities and at practicable prices metals which were formerly unknown or else mere chemical curiosities. It has, further, refined many metals to a degree of purity not previously known. The metallurgist is rapidly appreciating the possibilities of electrometallurgical methods, and they already form a considerable proportion of present metallurgical practice.

Applied electrochemistry, covering in general all of the field just described, is therefore an important part of chemistry and metallurgy, and is rapidly increasing in importance. It is a new art, people are really only beginning to understand its principles and to appreciate its possibilities; it is an art pursued by the most energetic and enterprising chemists, with the assistance of the most skilled electricians. Some of its most prominent exponents are electrical engineers who have been attracted by the vast possibilities opened up by these applications of electricity. The chemists have worked with electricity like children with a new toy, or a boy with a new machine; they have had the novel experience of seeing what wonders their newly applied agency could accomplish, and it is no exaggeration to say that they have astonished the world—and themselves.

THE AGENTS OF ELECTROCHEMISTRY.

The operating agent in electrochemistry is, of course, electric energy, which may be used in three classes of apparatus, viz.:

(I) Electrolytic Apparatus.
(II) Electric Arcs and Discharges in Gases.
(III) Electric Furnaces.

I. Electrolytic Apparatus.

Electrolytic apparatus and processes use or utilize the separating or decomposing power of the electric current. Whenever an electric current is sent through a liquid material which is compound in its nature, i. e., a chemical compound, the current tends to decompose the compound into two constituents, appearing respectively at the two points of contact of the electric conducting circuit with the liquid in question, i. e., at the surface or face of contact of the undecomposable conducting part of the circuit with the decomposable part. If the current has a definite direction the constituents appear at definite electrodes. The action is simply the result of the current extracting (or tending to extract) from the electrolyte one of its constituents at each of the two electrode surfaces. All subsequent changes following upon this primary tendency of the current are called secondary reactions, and are practically simultaneous with the primary. These may even be regarded as truly primary reactions also, the primitive decomposing or separating power of the current passing being regarded only as a *tendency* or a *determining* cause which practically results in the reactions actually taking place.

This agency is an extremely vigorous and potent force for producing chemical transformations. It enables us, for instance, to split up some of the strongest chemical compounds into their elementary constituents, to convert cheap materials, in short, to perform easily some very difficult chemical operations, and in some cases to perform chemical operations otherwise impossible. A description of all these various processes would take a volume, but a short explanation of a few of them will make the principles clear and suffice for my present purpose.

Electrolysis of Water: As a raw material, water may be said to cost nothing. Apply an electric current to it in the proper way, and it is resolved into its constituent gases, hydrogen and oxygen, as cleanly and perfectly as anyone could desire. These gases have many and various uses, and are valued each at several cents per pound. A whole industry has thus grown up, based on the simple electrolysis of water, to supply these two gases for various industrial uses. Europe possesses many of these plants; there are a few in the United States. The speaker has translated from the German a small treatise on this industry.

Electrolysis of Salt: Common salt, sodium chloride, is one of the cheapest of natural chemicals. It has some uses of its own, but centuries ago chemists and even alchemists devised chemical processes for transforming it into other sodium salts, such as caustic soda or soda lye for use in soap, soda ash or carbonate, for washing or glassmaking, and into chlorine bleaching materials. Chemical works operating these rather complicated chemical processes exist on an immense scale in all civilized countries; it is estimated that $50,000,000 is thus invested in Great Britain alone. The electrolytic alkali industry is barely twenty years old, yet it is already more than holding its own with the older chemical process, and advancing rapidly; twenty years more will probably see the older processes entirely superseded—they are at present fighting for their existence. As for the electrolytic process, the salt is simply dissolved in water and by the action of the current converted into caustic soda at one electrode and chlorine gas at the other. By some special devices these are kept separate and collected by themselves, and the work is done. The principles involved are simplicity itself as compared with the older chemical processes, the only agent consumed is electric energy, and the products are clean and pure.

Chlorates: These are salts used on matches and in gunpowder. Chlorate of potassium is a valuable salt with important uses. It is made from common cheap potassium chloride, in solution in water, by simply electrolyzing the solution without trying to separate the products forming at the electrodes. It is a simpler operation than the production of electrolytic alkali. Chlorate thus forms in the warm solution, and is obtained by letting the solution cool and the chlorate crystallize out. The ordinary chemical manufacture of this salt was tedious and dangerous; the electrolytic method has practically entirely superseded it.

Perchlorates: These salts have more limited uses, but are made by expensive chemical methods. The electrolysis of a chlorate solution at a low temperature, without separating the products formed at the two electrodes, results in the direct and easy production of perchlorates. I cite this more to illustrate what I might call the versatility of electrochemical methods, rather than because of its commercial importance.

Metallic Sodium: The caustic soda produced from salt can itself be electrolytically decomposed; this is the easiest way of producing metallic sodium. Sir Humphry Davy discovered sodium by electrolyzing melted caustic soda and at this moment several large works are working this method on an immense scale. The caustic contains sodium, hydrogen, and oxygen, and the current simply liberates the sodium as a molten metal and frees the other two as gases, which escape into the air. The process is simplicity itself—when the exact conditions are known and rigidly adhered to. Metallic sodium is a very useful material to the chemist, and the electrolytic method produces it at probably one-fourth the cost of making it in any purely chemical way.

Magnesium: This is a wonderfully light metal, whose chief use is in flash-light powders. Its compounds are abundant in nature, but its manufacture by any other than the electrolytic method is almost impracticable. The operation consists in simply passing the decomposing current through a fused magnesium salt—a chloride of magnesium and potassium found in abundance in Germany.

Aluminium: The most useful of the light metals; an element more abundant in nature than iron, yet which costs by chemical methods at least $1.00 per pound to produce; electrochemistry enables the makers to sell it at a profit at $0.25 per pound. This is probably the most useful metal given to the world by electrochemistry. Although the French chemist Deville obtained it by an electrolytic method in 1855, yet he had only the battery as a source of electric current, and the process was too costly. This very city of Pittsburg was the real cradle of the electrolytic manufacture of aluminium, when, in 1889, Mr. Chas. M. Hall, with the financial assistance of the Mellons and the business assistance of Capt. A. E. Hunt, commenced to work his process up at Thirty-third Street on the "West Side." The principle of the process is here again one of beautiful simplicity—when it is once made known. Aluminium oxide, abundant in nature, is infusible in ordinary furnaces, but easily melts and dissolves, like sugar in water, in certain very stable and liquid fused salts—double fluorides of aluminium and the alkali metals. On passing the electric current through this bath, the dissolved aluminium oxide is decomposed, appearing at the two electrodes as aluminium and oxygen respectively. When all the oxide is thus broken up, more is added, and the operation continues. One of the most difficult problems of ordinary chemistry is thus simply, neatly and effectively solved by electrochemistry. The lower cost of power at Niagara Falls drew the industry away from Pittsburg, in 1893, and it is now run on an immense scale at several places where water power is cheap and abundant. Mechanical power is, however, being produced cheaper every year; gas engines have halved the cost of such power, steam turbines on exhaust steam may even do better; there is no inherent impossibility in the return of the aluminium industry to the Pittsburg district. Many other factors besides cost of power bear on the question; cost of labor, abundance of labor, cost of carbon, coal for heating, various supplies, railroad freights, nearness to the consumers, and many other considerations must be taken into account. Aluminium is certainly destined to become the most important metal next to iron and steel, and, as far as one can now foresee, will always be produced electrochemically. To have accomplished the establishment of this one single industry, would itself have proved the usefulness of electrical methods and their importance to chemistry and metallurgy.

Refining of Metals: Unless metals are of high purity they are usually of very little usefulness. Electrolytic methods enable almost perfect purity to be easily attained, and in addition permit the separation at the same time of the valuable gold and silver contained in small amount in the baser metals. Over

* An address delivered at the Seventeenth General Meeting of the American Electrochemical Society in Pittsburg, Pa., and printed in the Transactions of the Society.

$100,000,000 worth of copper is electrically refined every year in the United States; the metal produced is purer than can be otherwise obtained, giving the electrical engineer the highest grade of conducting metal, while several million dollars' worth of gold and silver are recovered which would otherwise have to be allowed to remain in the copper. Again, the method is so simple that but a few words are necessary to set it forth in principle. The impure copper is used as one electrode—the anode—in a solution of copper sulphate containing some sulphuric acid; the receiving electrode—the cathode—is a thin sheet of pure copper, or of lead, greased. The electric action causes pure copper only to deposit upon the cathode, if a properly regulated current is used, while a corresponding amount of metal is dissolved from the anode. Silver, gold, and platinum are undissolved, and remain as mud or sediment in the bottom of the bath; other impurities may go into the solution, but are not deposited on the cathode if the current is kept low. The cost of this operation is small, and the results are so highly satisfactory that 90 per cent of all the copper produced is thus refined. Similar methods are in use for refining other metals, silver, gold, and lead are thus refined on a large scale; antimony, bismuth, tin, platinum, zinc, and even iron can be thus refined; the field is very inviting to the experimenter and to the technologist, and is rapidly increasing in industrial importance.

Metal Plating: All electro-plating is done by the use of electrolytic methods similar to those just described. If we imagine the impure metal anode replaced by pure metal, and the receiving cathode to be the object to be electro-plated, we have before us the electro-plating bath ready for action. Everybody knows the value and use of gold, silver, and nickel plating; less well known are platinum, cadmium, chromium, zinc, brass, and bronze plating. These are among the oldest of the electrochemical industries. Electrotyping is only a variation of this work; also the electrolytic reproduction of medals, engravings, cuts, etc., and even the production of metallic articles of various and complicated forms, such as tubes, needles, mirrors, vases, statues, etc. There is opportunity here to hardly more than catalogue these various branches of electrometallurgical activity. Pittsburg people will be interested, however, in knowing that many of the newer buildings in this city contain thousands of feet of electrical conduits zinc plated in splendid fashion by electrolysis, at a works within a few miles of this city. At McKeesport, tubes are coated by dipping into melted zinc, on an immense scale, but the electrolytic method is gaining a foothold, and we may live to see all galvanizing in reality practised as it is spelled. The removing of metallic tin from waste tin scrap is also accomplished on a large scale by the application of similar principles. It is being operated at a distance from Pittsburg, but your open-hearth furnaces use up annually thousands of tons of the scrap steel thus cleaned and saved for remanufacture into useful shape.

Without having mentioned or described more than a fraction of the electrolytic methods in actual industrial use, I hope that I have made clear the importance and extent of this kind of electrochemical processes. Assuming this, we will pass to the consideration of another, entirely different and yet important, class of apparatus and processes.

II. Electric Arcs and Discharges in Gases.

Electric arcs and high-tension discharges through gases are capable of producing some chemical compositions and decompositions which are very useful, and profitable to operate. This is a branch of electrochemistry which has not been as thoroughly studied as some others, its phenomena are not as thoroughly under control as electrolysis and electro-thermal reactions, and its possibilities are not as thoroughly understood or utilized.

Ozone is being made from air by the silent discharge of high-tension electric current. The apparatus is so far simplified as to be made in small units suitable for household use, ready to attach to a low-tension alternating current supply. The uses for the ozone thus produced are particularly for purifying water and air; it makes very impure water perfectly safe to drink, and purifies the air of assembly halls and sick-rooms, acting as an antiseptic. According to all appearances, this electrochemical doubling up of oxygen into a more efficient oxidizing form is developing into a simple and highly efficient aid to healthy living.

Nitric Acid is an expensive acid made from the natural alkaline nitrate salts, such as Chili saltpeter. These nitrates are the salvation of the agriculturist, for they furnish the ground with the necessary nitrogen which plants can assimilate. The Chili "nitrate kings" have gained many millions of dollars, even hundreds of millions, in thus supplying the world's demand for fertilizer. But, electrochemistry has another solution to this problem, which is rapidly rendering every country which adopts it independent of the foreign fertilizer. The air we breathe contains uncombined nitrogen and oxygen gases, which if combined and brought into contact with water furnish the exact constituents of nitric acid. The way to do this has been laboriously worked out, and the electric arc is the agent which does it. Air is simply blown into the electric arc, where it for an instant partakes of the enormous temperature, and on leaving the arc is cooled as quickly as possible. In the arc, the combination of nitrogen and oxygen is effected to a certain extent, and the mixture is cooled so suddenly that it does not find time to disunite. The nitrogen oxides thus obtained are drawn through water, and this solution of nitric acid is run upon soda, to produce sodium nitrate, or on lime to produce calcium nitrate, the latter called nitro-lime or "Norwegian saltpeter." These salts entirely replace the South American natural salt.

The materials used in this industry are air and lime, and to these is added electrical energy. Air is universal, lime cheap almost everywhere, and electrical energy is cheapest where water powers are most abundant. In Norway, water power can be developed and electrical energy supplied from it at a total cost of $4.00 to $8.00 per horse-power-year. Some other countries can do nearly as well. Under these conditions, almost every country can afford to make its own nitrates, and so be independent of other countries for the fertilizer needed in peace and the gunpowder used in war. Norway felicitates itself already on being thus independent; nearly 200,000 horse-power is being utilized there by a $15,000,000 syndicate, and the industry is spreading rapidly over Europe. The study of this problem, its solution, and the rapid development of this vigorous industry, is one of the most remarkable chapters in the history of recent industrial development. In this accomplishment, electrochemistry has signally aided the agriculturist, and demonstrably multiplied the food-supply resources of all civilized and highly-populated countries.

Boron is an element which has until recently defied the best efforts of chemists to isolate in a pure state. It is an element which may have important application in the manufacture of a high-class special steel—boron steel. Dr. Weintraub, one of our fellow members, has recently solved the problem of its production by an adaptation of the "oxygen-nitrogen" arc apparatus, and utilizing the same principle of introducing the material into the arc and very rapidly cooling the products obtained. We mention this not because of its great commercial importance at present, but because it shows how the "arc method" may be of wide application in solving other difficult chemical problems; it has opened before us a new method in chemical science, and may give birth to many and various new chemical industries.

(To be continued.)

The Question of Exercise

Why should men whose natural physical endowment was always above par and who have been famous for their powers—gridiron stars, crack oarsmen, sturdy tug-o'-war's men, record makers in field sports—succumb to maladies which their weaker brothers readily conquer? It cannot be fairly assumed that the type of disease was so much graver in their cases. We must look to other causes than this, and the heart tells us why. That organ had long been overtaxed, and had, after years of strenuous physical effort, become abnormally large and in turn become degenerate, so that it could no longer be relied upon to fight a battle which it might safely have waged without the previous strain.

This entire question is ably considered by Dr. Albert E. Sterne, in his presidential address before the Ohio Valley Medical Association.

"During the developmental years," he tells us, "the comparative demand made upon the heart is pretty well up to its limits all of the time, for with body growth there is constantly increasing tissue formation. This new tissue requires nourishment, and this can be conveyed only through the circulation. After what we term full growth has been reached there is relatively, and actually, less strain placed upon the heart, so that it can more readily respond to any unusual yet reasonable demand made upon its power. During the years of adolescence, however, while the heart is being taxed to its capacity most of the time, it cannot be safely asked to do too strenuous service. The growing boy or girl who complains of shortness of breath, pain in the side, and palpitation upon moderate or prolonged effort, instances this dictum clearly. Examples of this kind are so common as to require only the merest mention. After the developmental period, such phenomena become less frequent, even though the demand upon heart and blood vessels be considerably greater.

"By means of accurate apparatus the tension to which the circulation is subjected can be measured, and any increase or decrease from the normal be registered. Increase in tension, that is, force for the heart and elasticity for the arteries, means increased muscular effort and expenditure on the part of the heart. This the organ can safely give, if the demand be not too great or too constant; but only then, for it must be remembered that the heart is a muscle—indeed, a very powerful one, and, like every other muscle, it adds to its intrinsic volume through use; that is, it becomes enlarged. Once this condition becomes established, the heart continues to exert undue force automatically, and drives the blood too vigorously against the arterial walls, to the lasting detriment of the latter, which, striving to maintain their normal compensatory relationship, increase their own muscular coat, and herewith is established an abnormal condition, a true pathology, a real vicious cycle. Even in minor degree such a condition cannot be regarded lightly, as baneful effects in after-life are pretty sure to follow. Lowered resistance and lessened vitality are pretty certain sequelæ. In the major degrees the effects are really disastrous. Here we see often excessive idiopathic hypertrophy, or essential heart enlargement, due wholly to the constant strain which had been placed upon that organ, either at a period when it had all it could reasonably do to fulfill its normal duty, or after this period has been passed, by whipping it to activity beyond its potential capacity. Sooner or later every hypertrophic muscle undergoes degeneration, and every hypertrophic heart does the same thing. Yet even if it did not, the loss of elasticity of the arterial walls—the vital rubber of body tissue—would alone bring about general inanition.

"Purely on medical grounds, therefore, I am opposed to such forms of exercise for growing boys and girls especially. In my opinion, strenuous sports or athletics, of every description, which place an abnormal demand upon the circulation cannot be too emphatically condemned. They should have no place at all in our grade schools, intermediate or high schools, public or private, and be permitted only under rigid physical scrutiny even in the undergraduate classes of higher institutions of learning, associations, clubs, or whatever they be called, where the participants are not practically full grown and developed beyond the average.

In almost all of our universities and colleges, medical oversight of all aspirants to athletic honors is given. This is probably true also of some of our preparatory, private, and less frequently, public schools. But is this true of even a respectable minority? Moreover, this lack of scrutiny by competent medical authority is most apparent just where it is most essential—for the growing and half-grown boys and girls.

"Of all athletic sports, doubtless football makes the greatest and most constant physical demand. In minor schools it should be forbidden, not merely because of accidents, but chiefly because it is a sport for no weakling, even though grown. Football is a man's game in every sense, and then only for men above physical par. That what I have stated in regard to football is true, I believe experience will substantiate. It is a notable fact that men of powerful physique naturally, who have been in their day famous athletes, show a remarkable lack of resistance in later life, and frequently become victims of diseases which they should have been expected safely to weather. Instances of this sort have not been isolated. Indeed, they have occurred frequently enough to ask the reason."

The Propagation of the Sound of Explosion

Sources of sound of great intensity are immediately surrounded by a region of "normal audibility" of irregular extent, which is surrounded by a much larger region of "abnormal audibility," which, in certain cases which have recently been investigated, is separated from the inner region by a "silent" zone some 60 miles in width. G. von dem Borne offers the following explanation of these phenomena:

In the lower strata of the atmosphere, where the temperature decreases in ascending and the molecular weight of the air is sensibly constant, the acoustic rays are concave above; in the upper strata, on the contrary, they are concave below, because of the greater proportion of light gases of small molecular weight in the atmosphere, and the consequent increase in the velocity of sound. The wind exerts only a secondary effect upon the phenomena. The calculations of this scientist agree so well with the facts that the hypotheses upon which they are based, particularly in regard to the composition of the air at different heights, must be considered as expressing the essential truth. A more profound study of the phenomenon, in the case of volcanic eruptions for example, might give valuable information concerning the temperature of the upper air to a height of about 60 miles and the proportions of various gases in the atmosphere.

The Manufacture of Rolled "H" Beams*

A Review of Recent Practice

By G. E. Moore, M.I.M.E.

MANY inventors have devoted time and brain work to the perfection of the means for manufacturing rolled beams, and, of later years, more particularly to the manufacture of so-called "H" beams, or beams having flanges of great width as compared with the

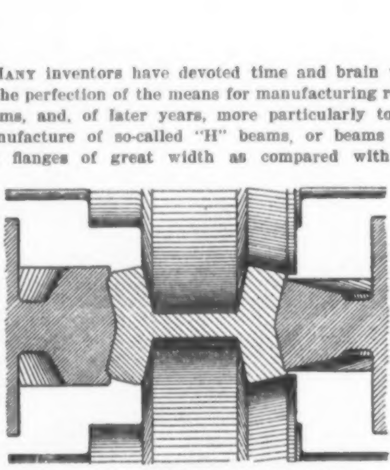


FIG. 1.—ROUGHING ROLLS OPEN

height of the beam. With ordinary two or three high mills, having grooved horizontal rolls only, the practical economic limit appears to have been reached in the case of the commercial standard sections; but beams of much larger section than these, and more particularly beams having relatively far wider flanges, are rolled more or less successively in universal mills

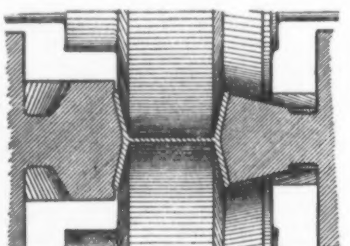


FIG. 2.—ROUGHING ROLLS CLOSED

which have both horizontal and vertical rolls. Moreover, with a universal mill a more economic distribution and better working up of the metal appears to be attainable than is the case with ordinary grooved rolls. Using grooved rolls only, the width of flanges which it is possible to roll is limited, not only by the necessity of using rolls of very large diameter to ac-

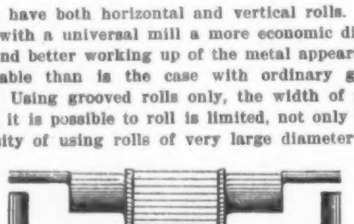


FIG. 3.—FINISHING ROLLS

commodate the deep grooves necessary to produce wide flanges and still leave sufficient metal in the rolls to give the necessary strength thereto, but also by the necessity of making such grooves with a very great inclination of their sides in order to avoid the tendency for the metal to become jammed therein, which

FIG. 4.—TWO-HIGH ROLLS OPEN

results in the flanges being weakened if not torn away altogether.

Universal mills having a pair of horizontal and a pair of vertical rolls all in the same vertical plane are now in operation, adapted to roll beams of much larger sizes than hitherto called for, or, say, up to about 30 inches high by 15 inches wide. But the prac-

* Iron and Steel Institute.

tical difficulties which had to be overcome to insure success in the production of such sections has necessarily involved a complication of the machinery used as compared with the mills customarily used to roll ordinary standard sections.

The difficulty of working up the metal in a complicated section, such as an "H" beam undoubtedly is, is

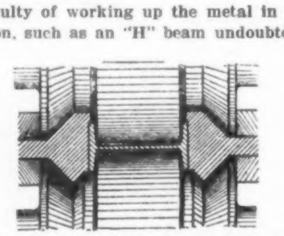


FIG. 5.—TWO-HIGH ROLLS CLOSED

to secure sufficient uniformity to avoid undue internal stresses, having regard to the comparative thinness of the metal in the web and flange necessary to enable them to be manufactured sufficiently cheaply to compete commercially with built-up beams. Another difficulty is that of producing finished beams of sufficiently good appearance, free from fins, eccentricity of web, and other irregularities. These are the chief

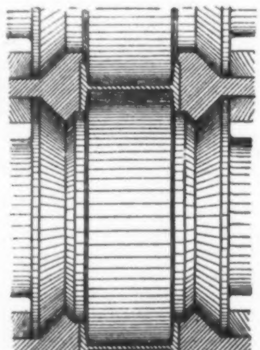


FIG. 6.—THREE-HIGH ROLLS

points which the inventor has had to watch, and to overcome which still taxes his ingenuity.

In what follows the author proposes first to describe briefly a few of the characteristic types of machines disclosed by different inventors through the medium of the Patent Office of the United States of America, to offer a few remarks thereon, and, finally, to present his own suggestions for criticism.

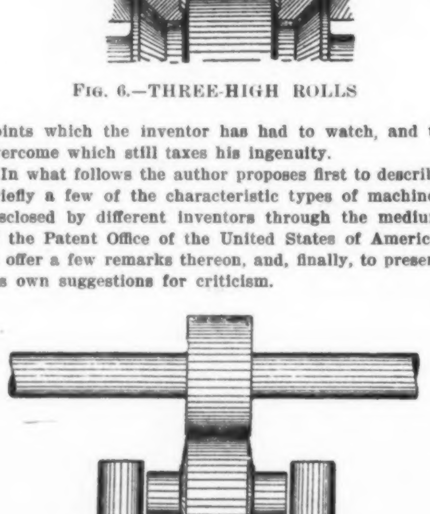


FIG. 7.—FIRST MILL

H. Sack, patent No. 365,100 (1887), describes a single reversing universal mill having a pair of horizontal rolls and a pair of vertical rolls with their axes all lying in one vertical plane, the two horizontal rolls being both alike but individually unsymmetrical, while the two vertical rolls are both different but individually symmetrical—Figs. 1 and 2. Thus the gaps between the rolls are, on one side, at the extreme outside edges of the flanges, and, on the other side, at the extreme inside edges of the flanges. After each pass between the rolls, the bar is tilted half round, and the positions of the flange edges relatively to the po-

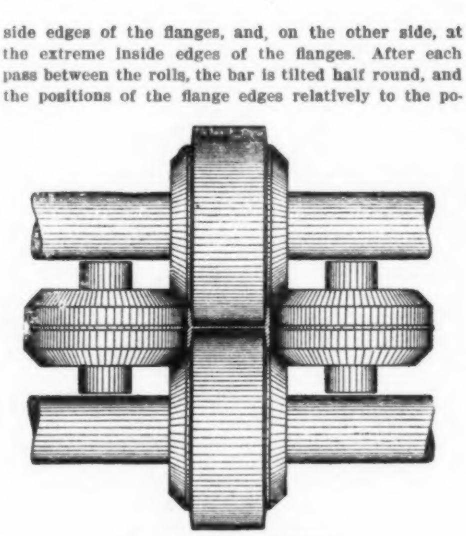


FIG. 8.—SECOND MILL

sition of the gaps between the rolls are reversed, and the edges which in one pass were adjacent to the gaps between the rolls are, in the subsequent pass, adjacent to the closed corners of the rolls. In this way the surplus metal extruded between the gaps of the rolls in one pass is rolled down and suppressed in the next.

The use of a single set of rolls for the reduction of the preliminary bar into a beam renders reversing and adjustment of the rolls after each pass necessary, and it is impracticable, with the rolls as described by H. Sack, and illustrated, to have a closed pass between them. At best, gaps are left at the corners of the flanges, which gradually become narrower as the pass is reduced and the blank rolled down, until the

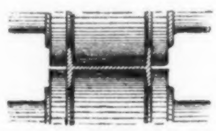


FIG. 9.—THIRD MILL

final adjustment is made prior to the final reduction, when the gaps are reduced to a minimum. Nor, even at the final pass, is it practicable to have an entirely closed pass, because, although the rolls may be adjusted prior to the final reduction so that they touch and the pass is practically closed, yet directly the bar enters the pass deflection takes place, which opens out the pass, and gaps are left between the rolls where fins will be formed on the bar.

With this method the section is developed with flanges outwardly bent from the longitudinal center line, in order to obtain a better rolling effect with the horizontal rolls upon the flanges, and this feature renders necessary the use of a finishing set of rolls—Fig. 3—through which the bar is passed after having been completely reduced in the previous set. The pass between these rolls need not be adjustable excepting to

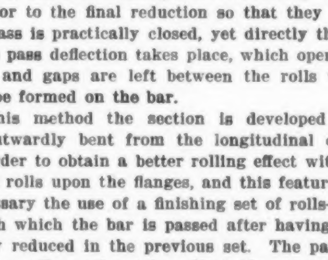


FIG. 10.—SINGLE REVERSING UNIVERSAL MILL

compensate for wear or displacement, and may be fixed in the ordinary way. Its shape is exactly that of the section required, so that the effect of passing the bar through these rolls is merely to square up the flanges and give a final finish to the bar, particularly at the corners of the flanges, where traces of surplus blank metal may have been left after reduction in the previous mill. No appreciable reduction need be given to

the bar in the finishing rolls, and, consequently, no appreciable deflection of the rolls takes place when the bar is passed through them; the pass, therefore, remains practically closed, and the formation of fins on the finished bar is avoided.

J. S. Seaman, patent No. 400,495 (1889), describes a single reversing universal mill having a pair of horizontal rolls and a pair of vertical rolls, with their axes all lying in one vertical plane, the two horizontal rolls being unlike each other but individually symmetrical, while two vertical rollers are both alike but individually unsymmetrical—Figs. 4 and 5. Thus, as in the Sack mill, the positions of the flange edges are changed relatively to the gaps between the rolls by tilting the bar half round after each pass, and thereby rolling down in one pass the surplus metal extruded between the gaps in the rolls in the previous pass. Or he proposes to attain the same result,

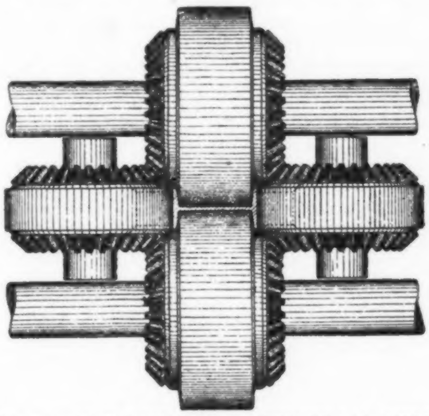


FIG. 11.—NON-REVERSING UNIVERSAL MILL

without tilting, by using a three-high universal mill having rolls of exactly similar construction to those described above, but with the top and bottom rolls alike and the center roll different—Fig. 6.

In this mill the bar is developed with straight flanges lying in a plane at right angles to the web, so that no subsequent straightening is required, and the bar may be finished in the one mill only.

J. Kennedy and H. Aiken, patent No. 410,107 (1889), describe a series of mills comprising three different types, each having a function distinct from that of the others.

The first is a reversing, roughing, universal mill, having adjustable horizontal and vertical rolls, with their axes all lying in one vertical plane—Fig. 7. In this it is proposed to reduce the ingot or bloom into approximately the finished form of beam required, by passing it several times backward and forward through the rolls, and adjusting the last together after each pass. When the bar emerges finally from the mill the sides and edges of the flanges are still

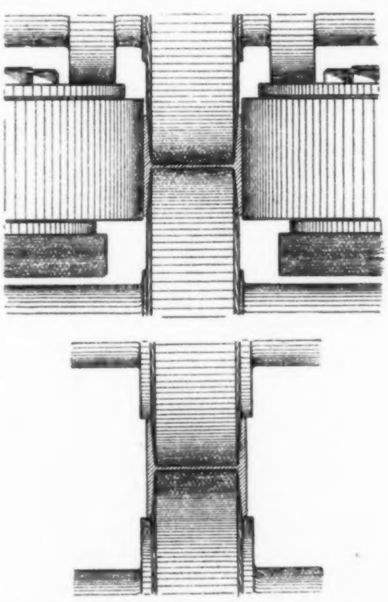


FIG. 12.—REVERSING UNIVERSAL MILL

rough, and it has consequently to undergo a further operation in the next mill.

The second mill—Fig. 8—is a non-reversing universal mill having non-adjustable horizontal and vertical rolls with their axes all lying in one vertical plane, and intended to reduce the sides of the flanges only. It is proposed to pass the bar through these once, and in order to secure effective co-operation between these and the subsequent rolls and to prevent the formation of fins, it is proposed to roll slight depressions in the center of each flange which the next operation will obliterate.

The third mill is a non-reversing two-high mill having non-adjustable horizontal rolls only, intended only to reduce the edges of the flanges—Fig. 9. It is proposed to pass the bar through them once to bring it to its finished form and to shape the edges, whereby the slight depressions formed along the center of the flanges in the previous mill will be exactly filled in this operation, and no fins will be left on the finished bar.

L. D. York, patent No. 410,724 (1889), covers a

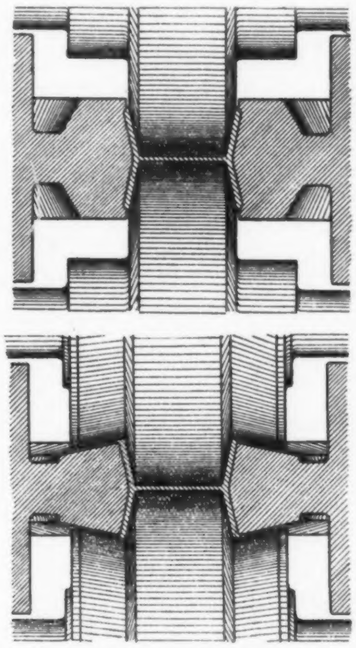


FIG. 13.—TWO MILLS ARRANGED SIDE BY SIDE

single reversing universal mill having a pair of horizontal rolls and a pair of vertical rolls with their axes all lying in one vertical plane, the horizontal rolls being both alike and symmetrical, and the two vertical rolls similarly both alike and symmetrical—Fig. 10. It does not transpire how the formation of fins is avoided, but some supplemental means would be required, as gaps must necessarily occur between the rolls until they have been adjusted to their ultimate positions prior to the final pass, and fins would inevitably be formed on the edges of the flanges of the bar.

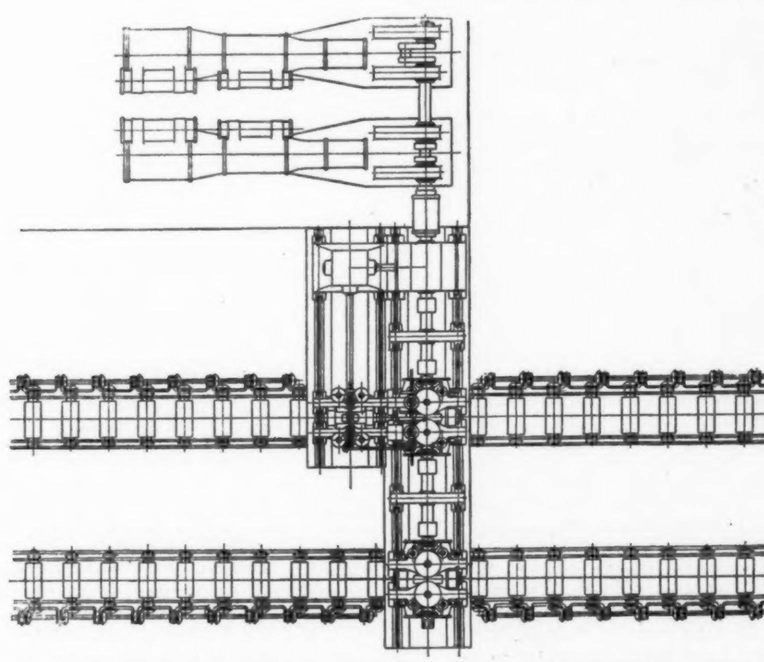


FIG. 16.—TANDEM SYSTEM OF ROLLING UNINTERRUPTEDLY BACKWARD AND FORWARD

E. M. Butz, patent No. 499,651 (1893), describes a series of non-reversing universal mills, each having a pair of horizontal rolls and a pair of vertical rolls with their axes all lying in one vertical plane, the two horizontal rolls being alike and symmetrical, and the two vertical rolls being similarly alike and symmetrical—Fig. 11. The rolls are non-adjustable, having a fixed pass, and the bloom is reduced by passing it once only through each set of rolls, the pass of which is narrower in each set than in the preceding set, until in the last set of rolls the pass has the exact contour of the finished beam. Thus, as many mills must be used as number of passes necessary to reduce a bloom into a finished beam, each mill having its rolls shaped ac-

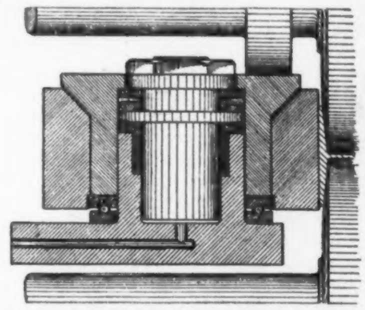


FIG. 14.—CONTACT BETWEEN ROLLS BY HYDRAULIC PRESSURE

cording to the reduction required to be given in each pass.

The rolls being fixed and the adjacent surfaces of the horizontal and vertical rolls being suitably shaped so that they are almost in contact with each other, it is probable that no very pronounced fins will be formed

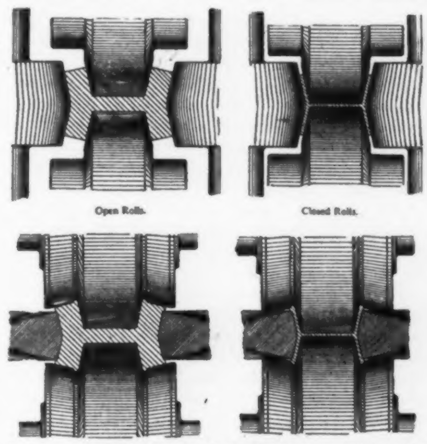


FIG. 15.—PRIMARY FOUR-ROLL REVERSING UNIVERSAL MILL

on the bar; but as it is not practicable to close the gaps between the rolls, particularly as during rolling considerable deflection takes place and the pass somewhat opens out, it is certain that at least beads, if not fins, would be formed on the corners of the bar flanges. Consequently, to obviate this, Butz proposes to use supplementary means to roll down the corners of the beam flanges adjacent to the gaps between the rolls. These consist of two small idle rollers, one on each side of the beam as it emerges from the main rolls, as shown dotted on the sketch—Fig. 11—and so adjusted that at each successive rolling operation the pass between the main rolls would be only just filled up at those corners, and there would not be sufficient metal to flow into the gaps and form fins. It ap-

pears, however, as if this arrangement would necessitate some means of supporting the flanges, as otherwise they would become bent, and consequently the corners would not be rolled down in the manner intended.

H. Grey, patent No. 587,958 (1897), describes a reversing universal mill having a pair of horizontal rolls and a pair of vertical rolls with their axes all lying in one vertical plane, the two horizontal rolls being alike and symmetrical, and the two vertical rolls being similarly alike and symmetrical—Fig. 12. This mill works in combination with a second mill having a pair of symmetrical horizontal rolls only. The first mill has rolls for shaping the web and sides of the flanges of the beam, but not the edges of the flanges; and the second mill has rolls for shaping the edges of the flanges only.

The two mills are situated as close together as possible, and have their driving and adjusting mechanisms connected together so that the bar passes through both sets of rolls as nearly simultaneously as possible with such an arrangement. Thus on one portion of the bar the flanges are being shaped on their edges, while a short distance farther on the sides of the flanges and the web are being formed, and the resulting beam is free from fins and presents a good appearance.

The foregoing systems of rolling beams devised by different inventors have been chosen as typical and to illustrate the means which experience teaches or ingenuity suggests might be adopted to overcome the chief difficulties which were mentioned at the beginning of this paper, each pointing out the direction in which the endeavors of the inventor were brought to bear, and each possessing features which, although involving complications as compared with the ideally simple plant represented by a pair of horizontal grooved rolls, yet to be considered, for the time being at least, as having their justification in the better quality of the product obtainable thereby or in the ease, cheapness, or speed of production.

The author does not assume, of course, that the systems he has chosen for his illustrations were all intended by their several inventors as means for manufacturing "H" or wide-flanged beams as differentiated from "I" beams or beams of the ordinary standard sections; but they illustrate some of the features which the practical designer of to-day is likely to take into consideration in evolving a mill suitable for the production of "H" or wide-flanged beams.

For the production of beams with abnormally wide flanges, in short, "H" beams, it may be assumed that a universal mill having four rolls—two horizontal and two vertical—all lying in one vertical plane is the simplest type of machine that can satisfactorily answer the purpose. A single reversing universal mill, requiring a tilting gear on each side, with which the bar is turned half round after each pass, is described by H. Sack and also by J. S. Seaman. These mills look simple, but evidently have drawbacks, due partly to the introduction of the tilting gears, which are complications in themselves, and are apt to require considerable time for their manipulation, particularly when the beam is long and bent; and partly also, perhaps, to the unsymmetrical section developed at each pass which, in the rolls described by H. Sack, would have the tendency to produce a bar bent sideways, and in those described by J. S. Seaman a bar bent vertically, so that very powerful guides would be required in the case of the heavier beams to keep the bar sufficiently straight as it emerges from the rolls to enable the tilting gears to operate satisfactorily. Briefly, in other words, the unsymmetrical rolls probably render other complications necessary in order to counteract their bending effect.

A three-high universal mill housed within one pair of stands only and requiring a lifting table on each side is described by J. S. Seaman—Fig. 6—and this would doubtless be a simple system to adopt if it were practicable to design the details of the roll satisfactorily and simply as regards the accommodation and adjustment of the vertical rolls in particular. Hitherto the author has not discovered a design of such an arrangement which would be considered satisfactory by himself or by the practical man.

Two mills arranged side by side, and having rolls such as those of H. Sack or by J. S. Seaman could be adopted and tilting avoided by making the horizontal rolls and the vertical rolls symmetrical in each case, but so formed that i one mill the edges of the flanges would be formed by the horizontal rolls only, and in the other mill by the vertical rolls only—Fig. 13.

Then after each pass the bar could be shifted from the one mill to the other, being rolled alternately in each mill until completely reduced. By this means the formation of fins would be avoided, but the plant would be considerably complicated, and as the centers of the passes in the rolls of the two mills could not conveniently be arranged very close together, the shifting gears would require to be particularly powerful and quick-acting in order not to lose much time over this operation.

A plurality of mills having universal rolls or horizontal rolls only, each mill intended for developing a certain portion of the section, is described by J. Kennedy and H. Aiken, and also by H. Grey; but whereas the former leave certain portions of the section to take care of themselves in the initial passes and to be worked upon in the final stages only, H. Grey works upon the whole section at every pass, and his system appears to possess advantages and to combine practicability and simplicity to a greater extent than the other systems hitherto described.

Finally, a series of universal mills, each working upon the whole section of the bar, but each adapted for one pass only, is described by E. M. Butz. This system would entail perhaps the maximum outlay on plant and machinery, and would possibly be adapted for the maximum production per unit of time. For rolling rails, of which thousands of tons of one section can be disposed of on a single contract, a plant of this description might possibly be a good investment, but for the manufacture of beams it seems more than doubtful whether it would be profitable to roll a sufficient quantity of each section to justify the expense of the plant and the time and trouble involved in changing so many sets of rolls for each section of beam.

Having dealt at some length with the various means adopted to overcome or prevent the formation of fins, which has been shown to be a matter of great importance calculated to influence enormously the design of the rolls, of the mill containing such rolls, and even of the disposition of the whole plant, some mention should be made of the other features of the designs illustrated for which they have also been specially selected.

J. S. Seaman, J. Kennedy and H. Aiken, E. M. Butz, and H. Grey have all endeavored to devise means for driving all the rolls of their universal mills, whereas H. Sack and L. D. York make no attempt to drive the vertical rolls, but content themselves with driving both the horizontal rolls and letting the vertical rolls rotate by contact with the moving bar as it is drawn through the pass by the driven horizontal rolls.

J. S. Seaman shows conical surfaces on the horizontal rolls engaging conical surfaces on the vertical rolls, contact being maintained between the two rolling surfaces by the pressure of the bar as it is squeezed between the rolls. This design has such grave defects that it cannot be regarded as mechanically sound enough for practical purposes; for, to be effective and avoid excessive wear and tear, the sides of the conical surfaces should be at such angles that, if prolonged, the apices of the cones represented by the prolonged sides would meet at the centers of the respective rolls, thus maintaining equal peripheral speed throughout the adjoining surfaces, in the same way as bevel gearing is designed. This is so obvious that it needs no further illustration; but if the vertical rolls were so designed their conical surfaces would make such acute angles that they would have a powerful wedge action, and, on application of the rolling pressure, component forces of excessive magnitude would occur, resulting in excessive deflection of the rolls, wear and tear, and probably a wrecked mill.

H. Grey shows a device whereby conical or cylindrical collars on the top horizontal roll engage, by frictional contact, with conical or flat surfaces on the vertical rolls by such means must be so limited as two by means of hydraulic pressure—Fig. 14. Like J. S. Seaman's design, this has also the defect that the peripheral speeds of the frictional surfaces are not constant throughout, and this defect cannot be remedied without introducing others as great or greater. Moreover, the driving force imparted to the vertical rolls by such means must be so limited as to render it inoperative for practical purposes. Altogether the device looks too unsound mechanically for practical purposes.

J. Kennedy and H. Aiken, in their second mill, show in contact conical surfaces which are designed on proper lines, but between which effective contact could hardly be maintained during rolling, for the pressure would cause deflection and spreading of the rolls; nor could sufficient pressure be applied in any case to render such contact very effective. They suggest, however, that the friction cones could be replaced by toothed gearing, and similar toothed gearing is also suggested by E. M. Butz; but in both cases, although a positive drive would be obtained, it would not be possible to adjust the rolls even slightly without interfering with the proper engagement of the gearing.

The neatest device for driving all four rolls while still maintaining adequate adjustment between them is that shown in the first mill by J. Kennedy and H. Aiken. In this case the rolling pressure on the horizontal rolls is directly utilized to furnish pressure to give the requisite frictional contact between the driven and the idle horizontal rolls, while the vertical rolls are positively driven by gearing. Such a device would doubtless give satisfactory practical results, although it is doubtful whether the results obtained thereby would compensate for the complications which it involved in the mechanism of the mill.

In the manufacture of "H" beams a bloom is usually first reduced in a blooming mill to a rough I-shape and thereafter operated upon and finished in the universal mill; and the idea that it is necessary to drive the vertical rolls in the universal mill as well as the horizontal rolls appears to be more theoretical than real.

The advantage of driving the vertical rolls instead of letting them run idle is most apparent before the bar has been gripped by the rolls as it enters the pass, and it is then conceivable that it would be easier to grip the bar if the vertical rolls were driven. Once the bar has been gripped by the driven horizontal rolls there is, however, no apparent drag upon it due to any lagging of the vertical rolls. In fact, if a tendency for the vertical rolls to lag behind were present no frictional device on the lines of any of those disclosed would be sufficiently powerful appreciably to diminish such a dragging effect.

The best conceivable frictional device for driving the idle vertical rolls is afforded as soon as the bar has been gripped by the rolling surfaces of the horizontal rolls and is in contact with those of the vertical rolls, and as before stated, an independent frictional drive could only serve a useful purpose providing it were sufficiently powerful, by helping to introduce the bar within the pass before it had been gripped by the horizontal rolls, but not otherwise.

In this connection the fact must not be overlooked that the horizontal rolls do not operate upon the web of the beam alone, but operate equally upon the sides and perhaps also upon the edges of the flanges. Thus it is not a case of the flanges being pulled through the rolls by a force imparted to the web, but as a matter of fact the flanges are directly gripped by the driven horizontal rolls, and the vertical rolls are only a form of surface for resisting the side pressure and participate in squeezing the bar, and have really no appreciable tendency to slip and lag behind. It is obvious, however, that the horizontal rolls will have a better grip upon the flanges the more the inside faces of these are inclined outwardly, and the greater the inclination the greater will be the rolling effect also. Consequently the author ventures to express the opinion that the method described by H. Sack, whereby the section is developed with the flanges outwardly bent from the horizontal center line, is not only peculiarly well adapted for rolling "H" beams having very wide flanges but the material in such beams should also be particularly well worked up and free from internal stresses.

The modern tendency is to reduce the inclination of the flanges of beams in order that the material may be better distributed by concentrating it as little as possible in the center of the section, and distributing it more outwards, in order to obtain a higher moment of inertia; and thereby greater strength for a given weight. This applies particularly to "H" beams intended to be used as columns, where the least moment of inertia must be used as a basis for calculating their resistance against buckling, and where the ideal section should have an equal moment of inertia in all directions.

Therefore, by so distributing the material in the flanges that a greater amount than formerly is concentrated on the edges of the flanges, and a proportionately lesser amount at the roots where they join the web, the moment of inertia is increased without increasing the weight of the beam.

Now, with the system described by H. Sack, the flanges can just as easily be made parallel throughout, or without any taper, as otherwise, thus obtaining the advantage of increased strength without adding to the weight of the beam. But in addition to this advantage, such beams possess the further advantage that they can be drilled and punched, rivet and bolt heads bedded, and connections with other members made much more easily and cheaply than the ordinary sections having flanges which taper however slightly. These advantages are, moreover, obtained without sacrificing in any way the quality of the materials, but rather the contrary is the case.

With all systems in which the flanges are developed straight—that is to say, with their outside surfaces at right angles to the plane of the web or nearly so—a certain inclination of the inside surfaces is essential to the proper performance of the rolling or reducing operations, and the more the taper is reduced the greater will be the risk of damaging the material, by reason of the greater tendency of the sides of the horizontal rolls to scrape away instead of rolling or squeezing away the inside surfaces of the flanges; and not only this, but also the greater will be the friction of the horizontal rolls on the inside surfaces of the flanges, and, consequently, the greater the wear and tear on the rolls.

It is obvious that the application of the system described by H. Sack will result in a better beam, a stronger beam, a beam with a better quality of material in it, and diminished wear and tear of rolls, as compared with other systems which do not develop the flanges in an outwardly bent state.

The author having been intimately associated with the late Mr. Hugo Sack, whom he assisted in the development of his ideas, has had the opportunity of making himself thoroughly conversant with the practical aspects of this particular process, and he feels convinced that no other system at present known is so well adapted to produce, commercially, "H" beams of a good, sound quality, as that which the late Mr. Hugo Sack invented nearly twenty-five years ago, and upon which he brought his masterly mind to bear with such persistent energy and enthusiasm.

The extensive trials carried on at the Rombach iron works have proved the soundness of the system, and they have shown that the direction in which improvements can still be made lies chiefly in the adaptation of the plant for producing large quantities of material on a commercial basis with a minimum outlay in capital expenditure and working cost. To this end the author has endeavored to apply the experience he has acquired, and ventures to give the results of his efforts in the succeeding.

From what has been stated in the foregoing, it will be understood that in order to produce "H" beams free from fins there is a choice of two distinct systems. First, the mill may be so constructed that one set of universal rolls operates upon the whole of the section excepting where the unavoidable gaps occur between the rolls, the positions of which gaps must be changed frequently or at every pass, this being attainable with one set of universal rolls forming an unsymmetrical pass as regards the location of the gaps, or with two sets of universal rolls, each forming a symmetrical pass, but each different as regards the location of the gaps—that is to say, using a single reversing universal mill and tilting the bar half round between the passes, or using two universal mills—which may be reversing or non-reversing—and shifting the bar from one to the other between the passes. Secondly, the mill may be so constructed that one set of universal rolls operates upon the greater portion of the section, and is adapted to reduce and elongate the bar as a whole, while a second set of rolls operates only upon those portions of the bar which are not operated upon in the first set, and are adapted to reduce the bar locally, but not to elongate it or reduce it as a whole—that is to say, using a primary reversing universal mill in tandem with a secondary reversing mill, the two situated so close together that the bar is operated upon by both at the same time, although on portions a short distance apart.

It is with the second of these systems that the author wishes to deal, because the first is already sufficiently well known, and because he believes that the second possesses greater possibilities of development in the direction of economy.

H. Grey uses a primary reversing universal mill with four rolls operating upon the web and the sides of the flanges of the bar, reducing and elongating the bar as a whole, but leaving the edges of the flanges untouched; and in tandem therewith a second reversing mill, having two rolls which guide the bar and operate upon the edges of the flanges only. Thus, in the tandem mill, at every pass the bar is operated upon all over, and the formation of fins is prevented.

Retaining the system of H. Sack, in which the beam is developed with outwardly bent flanges, the author suggests the employment of a primary reversing universal mill, having its four rolls shaped to operate upon the web and sides and edges of the flanges, with the gaps between them located somewhat short of the extreme edges of the flanges, and sufficiently wide to prevent the extruded metal from cooling too quickly, and, in tandem therewith, a secondary reversing universal mill, with rolls shaped to guide the bar and roll down the surplus metal extruded between the gaps of the primary rolls—Fig. 15.

Any irregularities which might still be left at the edges of the flanges after the last pass in this mill could then be eliminated altogether by properly shaping the rolls so that the final pass required to straighten out the flanges in the separate set of rolls would roll down or fill up any irregularities, as the case might be, and give the system a final finish all over. The tandem system of rolling has the advantage that the beam is reduced all over and extrusions of metal beyond the limits of the desired contour rolled down all in one pass, so that the mill may work uninterruptedly backward and forward, and no time is lost in tilting or shifting from one stand to another. The cost of the equipment should be very slightly, if anything, more than that of a single mill with a suitable tilting gear; but, even if the cost were considerably greater, it would be more than justified by the increased output and by the saving of the extra wages which would be incurred in the more elaborate manipulation. The plan of such a mill is shown in Fig. 16.

Where two stands are used, and the bar shifted from one to the other, an increased output might be looked for proportionate to the increase in the cost of the plant and wages, provided that two bars could be rolled simultaneously and non-reversing engines used, but it is just a question whether the quantity of a given section required to be rolled at one time would justify the additional capital outlay in the plant required for such an arrangement, having regard to the fact that the rolls in both stands could be adapted for only one size of beam at a time.

Various Finishes for Zinc

Some Interesting Technological Suggestions

Of all the metals entrusted to the electro plater for metalic coating or coloring, not one is so easy to handle as zinc; whether it is to be nickel, brass, copper, silver or gold-plated, or whether it is to be colored brown, gray, violet, blue, green, yellow or purple. Not only is the electroplating of zinc easier, but it is much the quickest accomplished. It is a fact, however, that one's whole attention is required for the work.

In nickel-plating zinc, particular care must be taken to remove all grease; if lime is employed for removing the grease, it must be washed off as quickly as possible because the zinc articles are very readily attacked by the lime. The best method of removing grease from zinc (Zn) is by boiling it in caustic soda (Na OH), keeping it constantly in motion, however. It is then brushed off in a watery decoction of Panama bark, rinsed in cold water (H_2O) and transferred to the rapid nickeling bath. More advantageous, however, is an ordinary "sitrate bath," because with its use, with a current of three to four volts, the object can be heavily nickeled in five minutes without moving it about.

In brass-plating zinc special care must be taken to scratch it well after a few minutes, and not with a steel, but with a circular brass wire brush. The opinion of many tradesmen that the scratching of brass or copper is purposeless is entirely wrong. The more an object is scratched, the heavier a deposit can be had. The brass bath for zinc consists of:

1,500 parts pure potash, H_2CO_3.
60 parts chloride of copper, $CuCl_2$.
105 parts chloride of zinc, $ZnCl_2$.
640 parts nitrate of ammonia, $N.H._4$.
30 parts cyanide of potassium, CN.
10,000 parts distilled water, H_2O.

This bath is used at a temperature of 77 to 86 deg. F., and with a current of three volts.

In copper-plating zinc, the same process is resorted to as in brass-plating, but the copper bath can be so made up that the scratching of the object may be omitted. It is composed as follows:

15 parts neutral acetate of copper, CnO.
12 parts spirits of salammoniac, NH_3 (Spec. grav. 0.96).
35 parts crystallized soda, Na_2CO_3.
15 parts pure sulphite of soda, Na_2SO_3.
16 parts cyanide of potassium (99 per cent) CN.
10,000 parts distilled water, H_2O.

If the articles to be copper-plated are of cast zinc it is better to use a copper bath with which scratching is requisite. Such a bath is made up as follows:

350 parts blue vitriol, $CuSO_4$.
1,500 parts seignette salt (potassio-sodic tartrate), CxH_6O_6.
800 parts caustic soda, NaOH.
100 parts spirits of salammoniac, NH_3.
10,000 parts distilled water, H_2O.

If cast zinc articles are scratched, any non-conducting casting residues that may be present will be eliminated and a much finer coating is obtained than without scratching.

When silver-plating zinc, special attention must be bestowed on thorough amalgamation. Every spot where the zinc has no coating of quick silver will, after the scratching, turn black in silver-plating, and the entire work will be useless. The amalgamation or quickening bath is made up as follows:

150 parts of cyanide of mercury, Hg $(CN)_2$.
150 parts cyanide of potassium, CN (99 per cent).
10,000 parts distilled water, H_2O.

Having assured ourselves that the object is well cleaned, it is then drawn quickly through the mercurial solution and rinsed off in clean water. After having been passed through once more, they are ready for the silver bath. If the perfect removal of grease is doubtful, then the quickening bath must be diluted with one-third the volume of distilled water, so that the zinc objects can be allowed to remain longer in the solution. Care is, however, necessary, for even the heaviest plates will crack in the quickening bath. In silver-plating a very strong current is turned on at once, but it is allowed to act for but a short time (one to one and a half minute) and the tension is reduced to one to two volts. After five minutes the goods are transferred at once to the scratching bench, and after washing another quickening is advisable. The density of the silver bath should be about 10 to 15 deg. Baumé.

The gilding of zinc calls for no very great experience. A slight cleaning (pickling) suffices, and the gold bath can be used as for other metals, the gold being dissolved in boiling hydrochloric acid. When the gold is all dissolved the chloride of gold ($AuCl_3$) is added to H_2O, cyanide of potassium being at the same time added.

Zinc can also be readily colored without the employment of current, red, for instance, in the following composition:

50 parts blue vitriol of copper, $CuSO_4$.
25 parts bi-carbonate of soda, Na_2CO_3.
10 parts tartar, $C_4H_5O_6K$.
10 parts sulphuric acid, H_2SO_4.
1,000 parts distilled water, H_2O.

The articles are immersed for a short time in the bath, which soon deposits a fairly heavy copper coating. Zinc, as a component of brass, cannot be brass plated without current, but is very easily gilded. For silver-plating it is likewise necessary to use the electric current.

The patina on zinc is produced as follows:

100 parts hypo-sulphite of soda, $HNaSO_4$.
1,000 parts distilled water, H_2O, at 100 deg. C.
50 parts English sulphuric acid, H_2SO_4 (stirring constantly).

In the decanted solution of about 60 deg. to 70 deg. C. (140 deg. to 158 deg. F.) of sulphite of soda Na_2SO_3 and sulphurous acid H_2SO_3 pickled pieces of sheet zinc are laid. After one to three minutes they acquire a pale green, very brilliant coating. By frequent treatment, the deposit is changed to the deepest gray color.

Iridescent colors are obtained in the following solution:

10 parts dry tartrate of copper, Cu_2OH_2O.
2 parts caustic soda, NaOH.
150 parts distilled water, H_2O.

According to the duration of the stay in this bath, we attain from a violet color to a very dark red.

If a marbleized finish is desired, pour on the sheet zinc, while the coloring is still wet, in some places, hydrochloric acid and, immediately after rinsing, a five per cent solution of sulphate of copper in H_2O.

To a previously mentioned solution of sulphurous acid add:

15 parts chrome alum $Cr_2 3SO_3 + K_2SO_4 + 24H_2O$.
15 parts hyposulphite of soda, $HNaSO_4$,

whereby a more brownish color is imparted to the plates.

A bronze finish can also be produced on cast zinc, but in this case a previous brass-plating is necessary. After this, the dried objects are painted with a solution of:

100 parts gold sulphur, SbS_5.
50 parts salammoniac, NH_3.
10 parts hyposulphite of soda, $HNaSO_4$.
50 parts acetate of alumina, Al_2O_3.

Dried in a warm stove, then again coated and after dying brushed with a soft brush. By dipping in a ten per cent solution of cyanide of potassium (CN in H_2O) the coating becomes black.

To color the zinc directly black, the arsenic bath, composed as follows, is used:

1,000 parts arsenic, As.
100 parts cyanide of potassium, CN, 99 per cent.
40,000 parts distilled water, H_2O.

The articles change from green to blue, red, brown, violet and slowly turn a deep black.—Translated from *Die Edelmetall-Industrie* for the SCIENTIFIC AMERICAN SUPPLEMENT.

A Remarkable American Forest Railway

The Profitable Industrial Road in Michoacan, Mexico

By A. Reiche

When the twin ribbons of steel blazed the way through the wild western lands, the United States began to grow with rapidity. The railroads opened untold possibilities and then developed them. The same thing, in a smaller degree, is and has been true in other countries, notably Mexico.

It is said by enlightened visitors to the republic presided over by President Porfirio Diaz that Mexico has been standing still because the majority of its inhabitants are ignorant. It has been the American who has carried a spirit of enterprise into the country, and turned the backward and unprogressive land into a progressive one which is now rapidly forging ahead.

Railroads have done their big share in Mexico's transformation, and no small part must be given to the industrial railways, the narrow-gage lines which pierce the density of the forest and unlock the doors of untold wealth that for years have been hidden because of no serviceable means of transportation. Over plains, through valleys and ravines, over mountains and through forests, the industrial railway has been pushed, establishing a means of easy communication between vast and wealthy plantations and the marts of trade in the centers of densely inhabited Mexico and along her seaboard.

One of the most profitable industrial railways through the Mexican forest is in service in the province of Michoacan, and extends from Huingo, a station on the line of the Mexican National Railway, to the hacienda San Joaquin Jaripeo. The province of Michoacan lies half way between Mexico City and the Pacific Ocean, and is in the foothills of the southern range of the Sierra Nayarit Mountains.

The hills and mountains in this part of Mexico are covered with a dense forest of oak and pine which grow to a height and size not often reached in the United States, as may be seen in the accompanying engravings.

On account of the rapid development of railways and mines in Mexico, and the coal deposits not having been developed to any considerable extent, there is a large demand for lumber, railroad ties, and wood for locomotive and furnace fuel uses. This demand is greatest in northern Mexico, and as the forests in Michoacan afford the nearest and best supply, it can be seen why great inducements were offered to the land owners to develop their timber property. This the owners of the hacienda San Joaquin Jaripeo, one of the largest estates in Mexico, did to some extent for several years; but as they were compelled to convey the timbers to the nearest railroad station, Huingo, by mule and by ox teams, very little progress was made, as they were not in a position to take large contracts, and the cost of haulage grew prohibitive as soon as the distance became larger.

They finally determined to construct a railroad for their own use and to develop their land on a large scale. The distance from Huingo to the hacienda is 24 kilometers (14.9 miles), and it was decided to build their mills at the hacienda, making the line from there to Huingo the main line, and therefore of fairly heavy construction, while from the hacienda out through the forests, branch or feeder lines were to be laid which would be of lighter construction, of narrow gage, and therefore could be easily shifted and moved as desired.

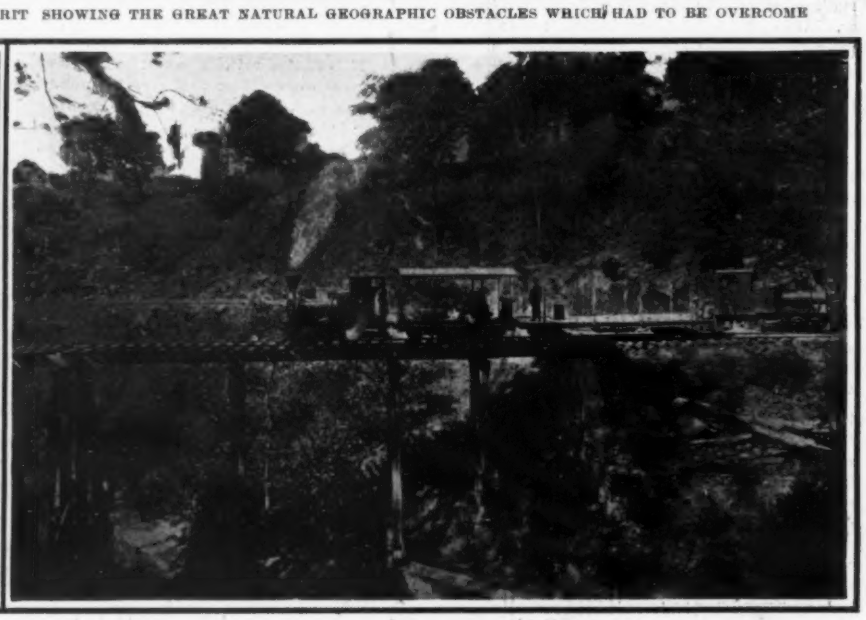
After consultation with a well-known Pittsburg company, it was decided to construct the main line of a 48-inch gage, or 1219.2 millimeters, while the branch lines were to be a 24-inch gage, or 609.6 millimeters.

They accordingly placed an order with the above-named company for the complete equipment, consisting of rails, switches, locomotives, and lumber cars.

From the survey it was found that the country sloped downward from the hacienda steeply for the whole distance, and that instead of having to plan the line to avoid grades against the loaded trains, it would be a question of making the grade small enough to permit locomotives of the ordinary type operating on it and at the same time have tractive power sufficient to haul back the empty cars. A line was finally laid out which averaged about five per cent down grade. This was accomplished partly by avoiding as much as possible all points which would cause heavy excavation or large fills and blasting of rock. While this policy made the line somewhat longer and with

A VIEW IN THE LOWER FOOTHILLS OF THE SIERRA NAYARIT SHOWING THE GREAT NATURAL GEOGRAPHIC OBSTACLES WHICH HAD TO BE OVERCOME

CUT THROUGH A HILL



TYPES OF THE ROLLING STOCK

A REMARKABLE AMERICAN FOREST RAILWAY

more degrees of curvature than would be regarded as standard practice in railroad construction, yet it avoided the necessity of using an extensive plant for construction work, and what was more essential, the need of skilled laborers.

The only labor obtainable in the surrounding country were the peons who lived on the hacienda; and as bids obtained for the construction work were enormously high on account of the remoteness of the place and the comparatively small job, the owners decided to do the work themselves by using only their own plantation laborers. This of course added to the length of the time the line was under construction, as the force at work varied at different seasons of the year according to the other demands on the laborers, but resulted in a very cheap construction account, in spite of the fact that it was not possible to avoid some very deep cuts and the construction of numerous bridges and trestles, as can be seen pictured in the illustrations.

The excavation work was done entirely with hand labor by pick and shovel, with the aid of an equipment of the well-known V-shaped double-side dump cars of one cubic yard capacity, and of portable track, which are built by the Koppel company. This outfit was ideal for the purpose, as the units were all light enough to be easily handled by a few men on any ground. The cars of course were hauled by mules or oxen.

The abundance of fine timber supplied the material for the bridges and trestles, and trestling was done wherever possible, as it required less skilled work than bridge construction called for, and the units to be handled were smaller.

Handling of rock was avoided as much as possible, as stated, and one of the illustrations shows a detour made to escape some boulders.

As soon as the main line was completed, which took about two years, the narrow gage lines radiating out from the hacienda were started and are being extended gradually, as required.

The equipment of the lines consists of platform cars, (for which the iron parts were purchased, the superstructure being built by the owners), locomotives of 40 and 50 horse-power for the main line, and lighter ones of 20 horse-power for the 24-inch gage lines. There are also some passenger cars and a private car for the use of the owners and their guests.

It can readily be seen that the only work done by the locomotive on the downward trips is in controlling the speed of the train by its braking power. A party from the ranch often takes the private car and runs down to Huingo, governing the car by brakes.

With regard to the cost of the line, no exact construction expenses were kept, but the total expenditure on the lines so far constructed, including equipment, has been from $600,000 to $700,000 Mexican, or $300,000 to $350,000 gold.

As soon as the main line was finished, the project was placed on a paying basis almost at once, as the owners were able to take large contracts for railway ties and fuel from the Mexican National at excellent prices.

Although the extent of this road is not so very great, and no great engineering works were involved in its construction, yet it is interesting from the fact that it was built and brought to a satisfactory conclusion by unskilled labor and by supervision through wild and mountainous country. It also shows the value of such narrow-gage or industrial railways for cheaply developing the resources of a country, which otherwise would be inaccessible for the use of mankind.

SKIRTING A HILLSIDE WHERE THE SKILL OF THE ENGINEER IS TAXED

ONE OF THE MANY STREAMS WHICH HAD TO BE CROSSED AND RECROSSED

SOME OF THE TIMBER

TRESTLE OVER A DEEP GORGE

A REMARKABLE AMERICAN FOREST RAILWAY

To coat iron with a covering of lead which will be in absolute metallic contact, states the Chemical Trades Journal, is a difficult operation. Valves and small fittings made of iron well galvanized on the exterior may be homogeneously covered with lead in the workshop by any mechanic. The method consists in immersing the piece to be coated in water to which a few drops of sulphuric acid have been added. Then, while in the acid water, the piece is readily amalgamated in the usual way by squeezing mercury through close-woven cloth all over its surface and thoroughly rubbing it in. The excess mercury is rubbed off and the piece carefully dried without heat, and then immersed in a bath of lead, which should be well above its melting point, so that it would not tend to solidify by introduction of the cold piece. The casting may be withdrawn after about 20 seconds, and will be found to be homogeneously covered with lead. This method requires the piece to be galvanized before applying the lead, and the galvanizing must be in good condition, otherwise the subsequent amalgamation will be imperfect. On account of the mercury fumes given off, it is not an operation one would wish to carry out day in and day out, and on large pieces, but the method is simple, and, of course, can be applied to any metal or alloy that can be amalgamated.

Science and Engineering*

Sir J. J. Thomson's Comments on a Vital Subject

CONSPICUOUS among the qualities which have raised Sir J. J. Thomson to a foremost position among living physicists has been the success with which he has been able to imagine working models of the complicated electrical processes which he has investigated with so much originality and power. He appears, indeed, to regard physical phenomena from the standpoint of the engineer, and not from that of the philosophic mathematician, whose equations are not pale reflections or images of subsensible particles of matter in motion, but merely a collection of recipes for acting or reacting on Nature. This latter mental attitude, at one time greatly favored in certain parts of the continent, is no doubt logically inexpungable, but it may be safely asserted to have been almost barren of results, being conducive neither to the establishment of new facts nor to the origination of fertile speculations. It is what may perhaps be termed Sir Joseph's "Faradian" methods of exposition which have rendered his annual course of lectures at the Royal Institution so peculiarly fascinating to those who, while desirous of learning something as to the present drift of the unceasing advance in matters scientific, have neither time nor opportunity to make a serious study of mathematical physics.

In his presidential address to the Junior Institution of Engineers, dealing with "The Relation of Pure Science to Engineering," Sir Joseph attributed his tendency, to regard physical phenomena as reducible to aggregates of matter in motion, to the fact that, like the late Henry Rowland, of Baltimore, he commenced life with the intention of becoming an engineer, and, in his case, studied to this end under Prof. Osborne Reynolds, one of the ablest and most original thinkers that has ever filled a professorial chair in engineering. Circumstances led Sir Joseph subsequently to choose a fresh path in life, and science has gained what engineering has lost. It would seem, however, that he has never seen reasons to regret his earlier training for a profession in which it is all-important to study actual phenomena, and not merely the mathematical forms by which their interrelations can be more or less successfully expressed.

In his address he claimed that the methods of the physicist and of the pioneer working in the engineering field are largely akin; and, indeed, Mr. Swinburne has expressed much the same view in one of his own presidential addresses. The difference between the two lies mainly in the aim. The physicist is in the fortunate position of being able to seek out the facts of Nature with no ulterior motive, while the engineer's groupings in the well of truth are in the main, to be quite frank, a hunt for dividends. The justification for his work must be found in the fact that, in one way or another, it must pay. Where this necessity is removed, as in government service, stagnation seems inevitably to result. A leading American authority has remarked that, up to the taking over of the telegraphs by the government, some thirty years ago, the improvements made were almost wholly of British origin; but since then they have been almost exclusively exotics, although in cable telegraphy, which remains in private hands, we still retain our supremacy as fertile and original workers. Similarly, the many thousand miles of state railways in operation abroad have contributed practically nothing to the solution of problems in transportation.

The luckier physicist, who finds his sphere in the laboratory or in the study, needs no commercial justification. Shallow thinkers will doubtless hold that the aim of the physicist must accordingly, from the standpoint of the moralist, be ranked higher than that of the engineer; but any attempt to institute an effective divorce between idealism and materialism is as futile as that to solve the famous problem as to the relative priority of the bird and the egg. The existence of the one presupposes that of the other, and while the world rightly honors those engaged in the pursuit of science for its own sake, such a pursuit is rendered possible solely by the fact that the engineer and the business man are attending to the more immediate and pressing necessities of mankind. He who invests in consols or municipal securities escapes, indeed, the thoughtless taunt of being a mere greedy hunter of dividends, but is, in truth, a less useful member of society than if, in the hope of a larger return, he had aided in the development of, say, the telephone, the steam turbine, or the aeroplane.

As was, perhaps, to be expected, Sir Joseph proved himself a strong advocate of the works laboratory and research department, and he remarked that the balance sheets of those firms whose laboratories were the most extensive did not suggest that they were ruining themselves in the cause of science. It would seem, however, that in many cases the laboratory is as much the result as the cause of large dividends. It is, indeed, impossible for a firm which returns its ordinary shareholders a mere 5 or 6 per cent in a good year, and nothing at all in a bad one, to embark on a large expenditure on pioneering work, which is necessarily of a highly speculative character. Such gambling risks can only be run by more prosperous undertakings, and the struggling firm has perforce to content itself with business of a more humdrum character. Fortunately, we still have some highly prosperous engineering firms who are in a position to make ventures in experimental work to the extent of many tens of thousands per annum. In mechanical engineering, however, the laboratory will always play a somewhat secondary part, its utility being much less marked than it is in the case of chemical and metallurgical establishments. The Parsons steam turbine, for example, was raised from little more than a toy to its present pre-eminence with appliances in the way of laboratory equipment which would excite the derision of a Continental engineer. One foreign firm noted for the lavishness of its expenditure on laboratory research is said to have expended nearly half a million sterling on the unsuccessful attempt to excel the Parsons machine, calling to its assistance university professors, demonstrators, and graduates in engineering, who were most liberally financed. However, in real pioneering the engineering laboratory probably counts for little. Ability of the first order is not purchasable at will in the open market, and the works laboratory is commonly staffed with less original men, who are, however, often extremely useful in developing ideas from outside.

Sir Joseph, in his address, raised a timely protest against the not uncommon, but short-sighted, contention that it is a wise plan to let "other nations spend their money in developing new processes, and to wait until the preliminary difficulties are overcome and success assured before taking them up." Against such a policy there are many arguments. Even as a matter of pure finance the practice is unsound. The profits of successful pioneering are extremely large. In the early day of the heavy electrical industry in this country dynamos costing some £30 to build readily sold for over £90, and the profits thus secured sufficed to build up an establishment which, starting with a total of some four of five hands, had become in three or four years the largest in the world engaged in that class of work, and employed hundreds of workmen. Its prosperity was then checked, and all possibility of further pioneering in the heavy electrical trades destroyed, so far as this country was concerned, by Mr. Joseph Chamberlain's disastrous Act of 1882. The fallen scepter passed to America and to Germany, where the enormous establishments of the A. E. G. not only pay regularly a high dividend to their fortunate shareholders, but the works themselves, with all their elaborate plant and equipment, stand on the books at but a nominal figure, having been written off out of profits.

The monetary returns attendant on successful pioneering constitute, however, only one of its advantages. The process opens a career to men whose *forte* lies in their originality rather than in their organizing ability or painstaking industry. Moreover, almost every firm that has tried it will, we think, admit that it is not possible to purchase experience over the counter along with working drawings. Many, for example, have taken up the manufacture of large gas engines to Continental designs, paying heavily for the privilege, in the fond belief that they would thus at once be able to put the construction of such engines on a manufacturing basis. In many cases, however, the transaction has resulted in serious loss and disappointment, and it has been necessary to spend large sums in acquiring, by trial and experiment, that experience which they vainly imagined they had secured by the simple process of purchase.

To no small degree this history is repeating itself in the case of Continental designs for steam turbines. An instance could be quoted of two firms engaged in a very similar class of work, both of whom decided to take up the manufacture of small steam turbines. The one purchased a Continental design, costly to build, and but moderately efficient, and have not yet attained to commercial success in spite of much work. The other firm, entering the field later, determined to build their own turbine *ab initio*, and succeeded. The very first built ran without a hitch from the start, gave most excellent results in the matter of steam economy, and actually cost less to construct than was paid in cash down for its Continental rival, which is, moreover, still subject to a royalty per horse-power turned out. It may be added that the firm bold enough to construct its own machine realized from the outset that the supposed necessity for employing technical students from Continental schools for such work is wholly imaginary, and is likely, owing to their imperfect knowledge of the practical side of engineering, to lead to serious losses of time, money, and material. The thermodynamic aspect of the steam turbine is, indeed, much less important than the mechanical, and a sufficient knowledge of the theory is not difficult to acquire.

In concluding his address, Sir Joseph insisted on the importance of a knowledge of mathematics to the engineer, and it is a view with which we have much sympathy, although it must be confessed that in mechanical and constructional engineering, as opposed to electrical, opportunities for the useful employment of higher mathematics are few and far between. Still the training is valuable, although experience has shown that certain types of men are inclined to use mathematical formulæ as a substitute for serious thought. The late Sir Benjamin Baker, had he had time for it, could probably have derived profit from even a minute study of the mathematical theory of elasticity. Smaller men, however, find it difficult to resist the temptation to design structures so as to simplify them mathematically, sacrificing to this end much more important considerations. Indeed, this tendency seems to have been at least partially responsible for the Quebec Bridge disaster, as it was also for the collapse not long ago of a very large shipbuilding crane supplied by a leading Continental firm. A well-known American engineer, again, has declared the use of plate girders to be most unscientific, since it is impossible to calculate with reasonable accuracy the stresses to which they are subjected. Riveted trusses meet the same condemnation, although experience with them, as with plate girders, has been most satisfactory.

At Winnipeg last year Sir Joseph drew attention to the great difficulties attendant on the application of mathematics to physics, and we believe that the difficulties are even greater in the case of mechanical engineering. The partial differential equations which arise in the mathematical theory of elasticity are, in fact, very much more complex than those of Laplace, which, we presume, may be taken as the basis of mathematical physics. It is, morever, even in solvable cases, extremely difficult, and, indeed, often impossible, to make the "boundary conditions," necessarily assumed, agree with actual practice. To this may be added the fact that no adequate theory as to "strength" of statically indeterminate structures exists, though the "stresses" can often be calculated with practical accuracy. Thus in New South Wales there are now standing, apparently satisfactorily, a number of reservoir dams in which the stresses calculated by the mathematical theory of elasticity exceed the breaking strength of the material; and we question whether an engineer well versed in this theory would have ventured to erect them. They are, nevertheless highly economical of materal, and prolonged experience of a somewhat similar type in the United States gives reason for believing that they are safe.

In fact, in all but the simplest class of structure or machine part the mechanical engineer has to rely upon "physical," rather than on strictly mathematical considerations. He forms an image in his own mind as to the general character of the stress distribution, and of the various ways in which failure may occur, and provides for these by somewhat rough-and-ready methods. In the case of the Assouan Dam, for instance, while his Continental colleague was much concerned as to the necessity of keeping calculated stresses below a certain limit, the late Sir Benjamin Baker attributed less importance to such considerations, since the severest stresses to which the structure would be subjected would, he knew, arise from incalculable changes of temperature. He paid special attention, accordingly, to the stability rather than to the strength of the structure.

The foregoing comments are not intended to belittle the importance of mathematical knowledge, but merely to draw attention to the extreme difficulty of applying mathematical theories in one particular, but very important, branch of engineering, and to draw attention to a certain danger, which experience has shown to exist, that a skilled mathematician may design a structure to suit his methods of computation rather than to carry its load in the most effective way. The mechanical engineer has, in practice, often to employ methods of reasoning akin to those of Faraday; and it is perhaps, doubtful whether it will ever be possible for a Clerk Maxwell to throw them into strict mathematical form.

* *Engineering.*

Trans-oceanic Aviation

An Analysis of Brucker's Project

THE recent long distance flights, demonstrating the improvements that have been effected in the construction of aeroplanes, both theoretically and mechanically, have revived, says Engineering, the interest in some ambitious schemes proposed to test the capacity and the outlook of aerial locomotion. Foremost among these is the plan to cross the Atlantic in an airship. Such a project had its origin in the fertile brain of an American journalist, Mr. Joseph Brucker, and his enthusiasm has so far affected others that a committee has been formed, which, on both technical and financial grounds, is capable of starting this project on the road to fulfilment. The scheme has advanced to the point of placing contracts with German firms of recognized standing, who are prepared to provide the necessary equipment, which will include, in addition to a dirigible balloon of large dimensions, a stout, seaworthy boat, to be attached to the airship, and to be used in case of accident to the aerial apparatus. The plan involves, therefore, not only the carriage of a certain number of passengers across the Atlantic, but also of a vessel, in which the journey might have been made. While we commend the caution thus exhibited, it is evident that trans-oceanic flight, handicapped in this manner, will make little progress.

The balloon itself is necessarily a serious affair, but far less capacious than a Zeppelin. It will be of elliptic form, about 160 feet long and nearly 50 feet in diameter in the center. To obviate the difficulties arising from solar radiation, the gas bag will be inclosed in an outer covering of some non-heat-conducting material, leaving an air space of 4 inches or 6 inches between this covering and the gas bag proper. At the same time a ballonet of peculiar construction, which is still a matter for experiment, will be provided. In this way it is assumed that the loss of gas will be reduced to a minimum, and no untoward circumstances arise from the inevitable heating of the balloon covering. Immediately under the balloon there is to be a platform capable of accommodating a crew, who will have to attend to the steering, balancing, gas control, etc.; and below this, again, in the place the car usually occupies, will be a substantial boat, 30 feet long and about 9 feet beam. In the hold of this boat will be carried a motor of some 40 horse-power, capable of revolving the air propeller, or, if adverse circumstances supervene, the screw of the boat when lowered into the water. This boat also carries a large tank of gasoline, provisions, kitchen galley, etc.

Numerous ingenious devices have been introduced, and that the scheme is practicable for a certain distance may possibly be admitted. But the step from covering a few hundred miles on land to one of some thousands over sea is a formidable one. It may not be too much to say that the risks increase with the square of the distance traversed. One would like to have more assurance on the question of navigation, or the accurate determination of position. Ocean currents of a slow-moving and well-recognized type, and of whose position the navigator is perfectly aware, can work very disastrously on ships, and it seems not impossible but that in the swifter and unknown aerial currents there may lurk a source of danger which has been very inadequately apprehended. One can imagine circumstances in which the compass would become useless, and sextant observations more uncertain than on the unstable deck of a ship. But the dangers threatened from these sources are so obvious that we may be sure they have been considered and provided for by the members of the committee of which we have spoken.

The proper course for the airship to follow has been a matter of grave consideration. The principle that determines the laying of a submarine cable does not apply here. The shortest course, naturally confined to high latitudes, is not the most suitable. The one factor to be considered is the prevailing direction of the wind, and this, when known, will decide both the most judicious course and the season of the year for the attempt. The air-current known as the "trade wind," which carried the frail bark of Columbus to a safe haven in the West Indian Isles, will be selected to carry the first airship above the waves of the Atlantic Ocean. The trade winds secure a tolerably uniform current of air in a zone varying little from 20 deg. north latitude. In the winter and spring months a velocity of from 14 to 16 miles an hour can be confidently anticipated, and these are also the months that are most free from disturbing cyclones. Therefore the attempt will be made in the spring, and the direction of the current from east to west decides that the aeronauts shall start from Europe and endeavor to reach America. Not only will the force and direction of this current prove of great assistance, but in the zone in which it obtains there is small variation in the daily temperature. Since it is desirable to keep the gas at a constant temperature, this fact is also in favor of the route, etc., of the scheme. The greatest chance of success, therefore, points to a course which, starting from Cadiz, will pass by Madeira and Teneriffe, and maintaining a generally W. S. W. direction, will endeavor to make Porto Rico. Thence along the chain of islands leading to Havana, this course is easy. On leaving Cuba, New Orleans will be the goal, and finally across the States to New York. The whole passage involves a journey of more than 7,000 miles, divided as follows:

	Miles.
Cadiz to Teneriffe	807
Teneriffe to Porto Rico	3,219
Porto Rico to Havana	1,124
Havana to New Orleans	674
New Orleans to New York	1,382

It is estimated that the journey across the ocean can be completed in five or six days, but the airship will be provided with gasoline and equipment for a much longer period.

Supposing the experiment is carried to a successful issue, it will be asked, What does it prove? What new scientific fact has been gained? What prospects does it open up for improved locomotion or more economical modes of transit? We must confess that, however dazzlingly the project may appeal to the imagination, however convincingly it displays the power of science and ingenuity, it will remain, we believe, a barren result. The promoters must naturally take a more hopeful view. It is for them to put forward some tempting by-products as an inducement, or as an excuse, for the expenditure and the risk. They urge that meteorology will be provided with more exact knowledge of the behavior of the trade winds, and of the motion of the upper atmosphere, while aeronautical problems will be studied on a scale which will remove the hindrances by which advance is now beset, and introduce processes that will revolutionize the ordinary methods of travel. Advocates of aviation foresee the construction of airships that will have a velocity which, combined with that of the trade wind, will transport the hardy aeronaut to America in the short space of fifty hours. We find it difficult to share these roseate views, at least as the result of a single experiment. What form aerial craft may be destined to assume in the future cannot be predicted, but as far as can be seen at present, high velocities are limited to the heavier-than-air machines. By constantly increasing the velocity the area of the supporting surface may be as continuously reduced, and this rule may point to the adoption of a form of helicopeter as the racing machine of the future. The possibilities of the dirigible balloon seem limited to being the burden-bearing machine of the future, capable of carrying considerable tonnage at a low speed. In this capacity a very useful career lies before it.

Fog Scales

IN the United States, observers of the Weather Bureau designate as a "dense" fog one that obscures objects at a distance of 1,000 feet. If objects are not obscured at that distance the fog is described as "light."

Is it desirable and feasible to describe the gradations of fog more minutely? English meteorologists have answered this question in the affirmative. The London Fog Inquiry of 1901-1902, conducted by the British Meteorological Office, gave precision to many of the ideas of meteorologists concerning fog, and one of the results of that inquiry was the adoption by the Meteorological Office and the Admiralty of a fog scale of five steps, as follows:

	ON LAND.	ON SEA.	ON RIVER.
Slight fog or mist.	1. Objects indistinct, but traffic by rail or road unimpeded.	Horizon invisible, but lights and landmarks visible at working distances.	Objects indistinct, but navigation unimpeded.
Moderate fog.	2. Traffic by rail requires additional caution. 3. Traffic by rail or road impeded.	Lights, passing vessels and landmarks generally indistinct under a mile. Fog signals are sounded.	Navigation impeded: additional caution required.
Thick fog.	4. Traffic by rail or road impeded. 5. Traffic by rail or road totally disorganized.	Ships' lights and vessels invisible at ¼ mile or less.	Navigation suspended.

For the determination of fog densities several forms of fog-gage have been proposed, though none of them have come into practical use. One suggested many years ago by G. J. Symons consisted of a white wooden screen, placed at a distance of 20 feet from the observer, on which were painted five black strips of different widths, the visibility of each strip corresponding to one of the five degrees of the fog-scale. At night this was replaced by a lantern in front of which were to be placed five thicknesses of colored glass; these were to be successively removed until the light became visible at a distance of 20 feet. A more elaborate form of apparatus, proposed by J. W. Lovibond in 1907, was based on the power of selective absorption resident in suitably colored glass, and measured the brightness of a fog on a scale of thirty-two "tintometrical light units."

During the past year the Meteorological Office has been making experiments to determine more precisely the distance of visibility at sea by day and night corresponding to the five degrees of the official fog-scale. The figures of the scale are based upon the interference of the fog with traffic, and it is desirable to form some definite idea as to how far off a vessel or light is visible, first, when a fog-horn is sounded by navigators as a matter of ordinary precaution, and secondly, when extreme caution is judged to be necessary. The matter has been taken up with the Elder Brethren of Trinity House, and arrangements have been made for observers at six lightships to note the state of atmospheric obscurity according to the numerical scale as judged by the requirements of traffic, and at the same time to note the distance of known land and sea marks which are visible or invisible. The returns from the lightships are now being examined in the Meteorological Office, and will form the subject of a special report.

Capt. R. E. Peary, famous for his expeditions in Arctic regions, culminating in his discovery of the North Pole, has deposited in the United States National Museum the series of sixteen gold and two silver medals that have been awarded to him. They include especially the great gold medal of the National Geographic Society of Washington, presented to him for his "discovery of the North Pole," and the great gold medal of the Royal Geographical Society of London, designed by Mrs. Scott, wife of the leader of the British South Polar Expeditions, and presented to Capt. Peary for "Arctic Exploration, 1886-1909." Also the following gold medals from American societies: The Cullum medal (first award, 1892) and the C. P. Daly medal of the American Geographical Society of New York (first award, 1902), the Hubbard medal of the National Geographic Society (first award, 1906), the Elisha Kent Kane (1902) and the special medal (1909) of the Philadelphia Geographical Society, and the Helen Culver medal of the Chicago Geographical Society (1910). The foreign medals received by him include the following, all of which are of gold except the two specially indicated as of silver: Royal Scottish Geographical Society (1897) silver, Royal Geographical Society of London (1898), Nachtigal medal of the Imperial German Geographical Society, Hauor medal of the Imperial Austrian Geographical Society (silver), the Paris Geographical Society, David Livingstone medal of the Royal Scottish Geographical Society (1903), King Humbert medal of the Royal Italian Geographical Society (1909), Royal Geographical Society of Belgium (1909), Royal Geographical Society of Antwerp (1910), and the Royal Hungarian Geographical Society (1910). Capt. Peary has also deposited in the National Museum the flag of his college fraternity, which was presented to him by his brothers of the Delta Kappa Epsilon, and the Peace Flag, which was presented to him by the ladies of the Society of the Daughters of the American Revolution. Both of these flags he carried to the North Pole.

European Transformer Towers

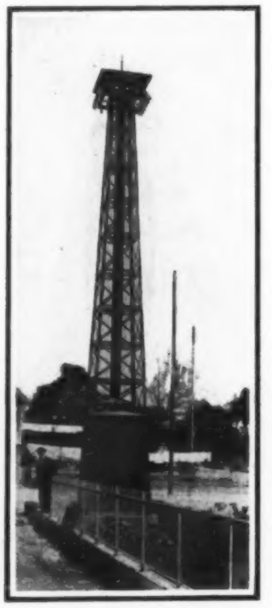
A New Type of Small-Sized Station

By the Berlin Correspondent of the Scientific American

A very suitable type of small-sized transformer station has been developed by the Oerlikon Machine Works, which shows a number of advantages over masonry stations. Apart from a considerable reduction in first cost and the possibility of readily shifting the station whenever required, they are in fact fitted up completely at the factory and after being installed on their foundation, are got into working order merely by connecting up the primary and secondary conductors as well as the transformer. Owing to their pleasant exterior and small space requirements these stations can be installed anywhere in the midst of other buildings, the more so as their painting can be adapted to the surroundings.

Transformer towers are generally made of frame work, comprising at the base a cabin for receiving the transformer and apparatus; being designed as lattice poles, they are of a very pleasant appearance and afford a point of support both safe and simple for use in connecting up any kind of conductor.

TRANSFORMER TOWER. HIGH-TENSION SIDE



GENERAL VIEW OF TRANSFORMER TOWER

TRANSFORMER TOWER. LOW-TENSION SIDE

The cabin is so designed as to afford ample space for a straightforward arrangement of all the apparatus and conductors. It is generally fitted with two operating doors, for the purpose of controlling the high and low tension ends respectively, but can be as well made accessible from all four sides. The most up-to-date apparatus have been provided for the protection and superintendence of the transformer.

A galvanized sheet-iron tube 30 to 60 centimeters (11.81 to 23.62 inches) in diameter is used for introducing the primary conductors into the cabin. At each of its ends a cast-iron spider is fitted in its interior and it carries the tightening device for three or six bare copper wires. The sheet-iron tube below the upper roof of the tower rises to a height sufficient to prevent any rain from penetrating into its interior and accordingly into the cabin. The secondary conductors (14 wires as a maximum) are taken out of the cabin by porcelain pipes protected against rain by a special roof, which at the outside of the sheet iron tube are likewise, arranged in the form of bare conductors.

The admission of fresh air is effected through apertures in the foundation, a lively ventilation of the transformer being insured by the violent draught in the admission tube. These apertures are arranged in the top part of the foundation, immediately below the iron foot of the tower. Another arrangement which, though somewhat more expensive, is considerably better, excluding as it does the entering of splash into the interior of the cabin, comprises an aperture closed with a perforated plate on one side of the foundation and through which a supply of fresh air below the transformer is allowed to penetrate directly into the cabin.

Any water oozing out in cold weather inside the sheet-iron tube is allowed to escape through an aperture in its lower end.

The transformer towers above described are designed in three sizes, the space available for the transformer having the following dimensions:

Size.	Length in meters.	Height in meters.	Width in meters.
A	1.0 (3.28 feet)	1.5 (4.92 feet)	0.7 (2.30 feet)
B	1.2 (3.94 feet)	1.5 (4.92 feet)	0.9 (2.95 feet)
C	1.3 (4.26 feet)	1.5 (4.92 feet)	1.0 (3.28 feet)

The largest size suffices for the installation of a transformer of fairly large dimensions, unless it be preferred to put up two small-size transformer towers, the secondary bus bar being provided with switches for use in allowing the transformers to work separately or in parallel.

In connection with another type of transformer tower, the whole iron structure is coated with "Eternite" plates fixed in position by zinc or copper sheets.

Electric Locomotives for Lotschberg Railroad

Two electric locomotives are now being built for the Bernese Alps railroad of Switzerland, which crosses the mountains by the Lötschberg tunnel and makes connection between the northern Swiss railroads and the Simplon line. Of the new railroad line there is already built a section at the commencement from Spiez to Frutigen. The locomotives will be run upon this section, and it is now being fitted with the trolley wire for this purpose. The company will thus obtain the necessary data for building the standard locomotives which are needed. Owing to the heavy gradients, adhesion is a prominent factor, while speed is of less consequence. The Swiss Oerlihon firm is building a 2,000-horse-power locomotive. It works on single-phase current at 15,000 volts taken by trolley. There are used two bogies, each carrying one motor and three driving axles. All the wheels are used for adhesion. The 1,000-horse-power motor of each truck drives a countershaft by 1:3.25 ratio gearing. Crank and bar drive is used to couple to the wheels. All the wheels of one side are connected together in turn by crank and bar drive. A single motor thus drives the three wheels. The same drive is used for each truck. The total weight of the locomotive is 95 tons, of which the electrical outfit represents 46 tons. The wheels have a uniform diameter of 1.35 meters (4.45 feet). As to the mechanical part of the locomotive, it is built by the Swiss Locomotive Works. The second locomotive is built by the Allgemeine Electric Company of Berlin and the Krauss manufacturing firm. An entirely different construction is used. Two separate half-locomotives, each mounted on a three-wheeled truck, are coupled together. The truck in each case has two driving wheels on a side and one pony wheel. When coupled, the entire locomotive presents four driving wheels at the middle and a pony wheel at each end. Weighing in all 102 tons, is uses 75 tons for adhesion on the four axles. The large wheel diameter is 1.27 meters (4.17 feet) and the small wheel 0.85 meter (2.79 feet). On each truck is an 800-horse-power single-phase motor of the German Winter-Eichberg type, making 1,600 horsepower in all, which is somewhat less than for the preceding type. A reduction gearing to countershaft and crank drive thence to the wheels somewhat analogous to the above, is employed here. The two wheels are coupled by a driving bar. The present locomotives have about the same capacity as the Simplon locomotives, which are built for 1,700 horse-power. However, there are radical differences in the design.

Our Myriad Government Publications

Of 1,982 department publications issued, 25,160,469 copies were printed, an increase of 46 2/3 per cent in the number of publications and 41 per cent in the number of copies. The Superintendent of Documents sold 147,327 copies of the department's publications. The number of copies sold has increased 205 per cent within five years. Of the Farmers' Bulletin on "Economical Use of Meat in the Home," 47,148 copies were sold, although 900,000 were distributed free. Forty-five new Farmers' Bulletins were issued, with a total of 2,915,000 copies; reprints of older numbers aggregated 6,247,500 copies. The expenditure for printing and binding was $441,349.94.

A Novel System of Cleaning Water Mains

In a system of cleaning water mains invented by Mr. R. A. Adamson, the engineer at the Rivington Works, an opening of 9 feet is made in the main to be cleaned, and a bracket is fixed on each end of the opening. These brackets carry two rails and a screw of coarse pitch. A gasoline engine is then lowered into the hole so that the wheels on the frame rest on the rails, while the screw passes through the center of the machine. The shaft of the engine is then central with the main. The frame of the machine is fitted with a hand wheel, by turning which the machine is propelled along the rails in either direction by means of the screw. A specially constructed knife formed of a central bar carrying four cutters is used for the scraping, and is attached to the shaft of the machine. The engine having been started up, the driver turns the hand wheel in the desired direction of travel, the result being that the revolving knife is gradually fed into the pipe after the manner of a boring machine. The apparatus is such that in long lengths it is possible to clean 200 yards in each direction from the hole, or 400 yards in all. The speed of cleaning is about 50 yards an hour, or in ordinary practice an average of about 300 yards a day. The appliance has been seen in actual operation at Huyton by a number of water engineers, while the members of the Liverpool Corporation Water Committee are so impressed with its labor-saving properties that they have decided to adopt it, and a machine has been ordered.

Apotheosis and the Worship of Ancestors

Eagle, Peacock, and Serpent and their Significance in Roman Times

By P. F. Mottelay

ONE of the prominent members of the French Academy of Sciences recently called attention to the recent discovery of funeral monuments of the early Roman period bearing novel designs of the eagle, Jupiter's bird, which had taken the place of the Egyptian hawk, and was made to play such a very conspicuous part in the Apotheosis (*Consecratio*) of Roman emperors.

Very curious and singularly interesting are the comparatively little-known details of the origin and progress of the rite of deification or consecration which at one time obtained so extensively for the Cæsars.

Apotheosis is the natural outcome of the progressive worship of ancestors. The more the latter had distinguished themselves in private or in public life, the greater, of course, was the reverence paid them. To rulers of men, who are ever prominently, majestically, before the world will always deservedly attach that amount of admiration which their exalted position and their attractive surroundings necessarily command, and the greater the popularity they achieve through personal valorous deeds or by means of victories obtained either on field or otherwise for the benefit and aggrandizement of their states, as well as for acts benefiting their fellow men, the greater naturally will be the honors and admiration accorded them by their immediate followers, their family, and their descendants.

The founder, for instance, at his death became, as others, the common ancestor for all ensuing generations, and, for the city, he was what the earliest ancestor had been for the family. His memory was easily perpetuated, and, later on, in accordance with the customs prevailing, yearly feasts were regularly held over his tomb and even sacrifices were made in his memory. His fame grew at great pace, and the increased honors attaching thereto which were gradually paid him extended afar, so that beyond his original home and beyond his actual burial place, as is pretty much everywhere the custom even at the present day, honorary tombs and monuments were in due time erected to his memory. As years progressed the story of the founder's deeds was amplified, around it was weaved a more or less marvelous legend, while the poets and the writers consecrated it in records that were, after awhile, embellished and heightened to such an extent that the human original himself actually disappeared and he had become transformed into a being worthy of worship, a god. Thus it was Athens came to deify her two founders, Cecrops, the first king of Attica, and Theseus, the great hero of Attic legend. Thus also, Romulus, founder and king of Rome, was proclaimed a god by the Senate, as is well known, under the name of Quirinus.

FIG. 1.—STRUCTURE BUILT FOR THE RITE OF APOTHEOSIS

In Egypt, where the ruling king was held as a god and was rendered anew all the honors bestowed upon his predecessors, the soul of the dead was first represented leaving the earth in the shape of a bird, then the bird was shown as carrying the soul itself. This idea of the soul-bird is borrowed from the stellar mythology teaching us that the sun is creator of souls: by the sun is the soul created in human bodies and by the sun also is it recalled to heaven. In Syria, the sun-god was himself represented borne upon the wings of an eagle. It was at Hieropolis (Hierapolis), a city of Syria Cyrrhestica, that the goddess Atargatis had one of her most famous temples. Atargatis was called by the Greeks Derceto and was worshiped under different names throughout pretty much the whole of Western Asia, where are found many funeral monuments bearing an eagle, the latter with outspread wings flying upward carrying a wreath in its beak or claws. The wreath, by the way, denoted the victory of the soul over the evil one and it was said that the gods turned aside from those appearing before them without wreaths. This silent form of deification at first prevailed everywhere, but, later on, when the body of an illustrious dead was burned upon an altar, an eagle was dispatched supposedly bearing heavenward the soul of the deceased. This had been described by many authors, but by none more satisfactorily than by Herodian and Dion Cassius. Their account of the customary ceremonies we think worth reproducing:

FIG. 3.—BRONZE MEDAL OF ANTONINUS PIUS

FIG. 2.—REVERSE OF BRONZE MEDAL OF SEVERUS

FIG. 4.—OBVERSE AND REVERSE OF SILVER COIN OF VALERIUS

There is placed in the palace vestibule, upon a bed made of ivory and covered with a cloth of gold, a waxen image of the dead representing him as still suffering and over whom guard is to be maintained for seven days. At intervals during that period, Roman Senators stand in black robes to the left of the image, while, to the right and in white robes, stand the ladies of the court and others holding high rank. The doctors are daily in attendance and go through the form of recording the progressive decline in health of their patient until his death is finally announced. When that is done, the most distinguished dignitaries of the empire, the senators and others, carrying the couch bearing the real body, likewise the bed holding the waxen image, to the Campus Martius and place them upon one of the tiers of a high pyramidal structure which has been erected there, covered with rich gold tapestries and ornamented by statues of ivory and by fine paintings, and which has been filled with aromatic and other similar substances, with much incense and perfumes, as well as with offerings of all kinds. This being concluded, the court dignitaries and the military ride three times around the structure (*Decursio*), accompanied by chariots whose drivers wear flying purple robes and hold waving banners whereon are recorded the great deeds of happy rulers. Then the reigning monarch fires the structure, from the very top of which is allowed to escape an eagle, mounting through flame and smoke into the sky for the purpose of carrying, it is believed, the soul of the dead from earth to heaven, in order that the deceased may thereafter be worshipped with the other gods.

FIG. 6.—REVERSE OF BRONZE MEDAL OF FAUSTINA

FIG. 5.—REVERSE OF MEDAL OF MARINIANA

It was in Rome that the apotheosis took its most regular form. The first, after Romulus, upon whom apotheosis was officially conferred was Caius Julius Cæsar (100-44 B. C.), and, after the victory of the triumvirs, the senate bestowed upon him the name of *Divus Julius*, the word *divus* having been employed in the same manner as *deus*. The fact that during the brilliant ceremonies of his apotheosis, a comet appeared, was taken as a sign and, to Augustus, was proof conclusive that the soul of Cæsar had already been welcomed by the immortals. C. T. Octavius Augustus (63 B. C.-14 A. D.) was the next to receive apotheosis and the ceremonies were the same as described by Herodian The fire, it is said, lasted five full days and into it the soldiers cast the arms borne by them during the ceremony as well as the medals and other rewards that Augustus had conferred upon them, while the women cast in their jewelry and other ornaments and many of their vestments. *Divus Augustus* was the name afterward given. When apotheosis was accorded to the emperor Antoninus Pius, successor to Hadrian (86-161 A. D.) and to Faustina, his wife (104-141 A. D.), two eagles were sent from the funeral pyre. For the Roman emperor Publius Helvius Pertinax, "the Galba of his time," successor of Commodus, unusually fine ceremonies were observed. His statue, made of solid gold, was carried upon a chariot drawn by elephants and the very high structure upon which the body was consumed was constructed of the finest woods and bore very many large ornaments of gold and of ivory. This latter substance was, by the way, always used by the Romans for decorating the temples of the gods, for the construction of thrones, and for the ornamentation of the highest insignia.

FIG. 7.—SUPERB BRONZE DISK FROM BRUSSELS MUSEUM, SHOWING BAAL THE SUN-GOD

The English poet Dryden thus refers to the rite of apotheosis in the opening lines of "Heroic Stanzas on the Death of the Lord Protector, Oliver Cromwell" (English Poets, London, 1810, vol. viii., p. 498):

"And now 'tis time; for their officious haste,
Who would before have borne him to the sky,
Like eager Romans, 'ere all rites were past
Did let too soon the sacred eagle fly."

Incidentally, it may be mentioned that the Greeks and the Hindus, more particularly, burned the bodies of their dead. Among the Greeks, it was the custom to burn the body after having bathed it in expensive oils and clothed it in most attractive vestments. When the body was consumed, the fire remnants were extinguished with wine, then the ashes were sprinkled over with oils and with more wine, after which the dishes were collected and placed in urns or other

receptacles. The Hindus held fire as one of their gods (*Rig Veda*, 14, 157) under the name of *Agni*, which carried the soul to the home of the blessed. Like some of the other eastern people, the Persians, on the other hand, did not burn their dead, nor did they decorate the bodies with ornaments of gold, that metal being of the color of the fire which they worshipped. When a king died, all the people of Asia were commanded to extinguish the sacred fire in their temples, not to be relighted till after the funeral ceremonies. The royal Persian tombs, it may be added, were always practically under guard, that of Darius having thus been looked after for a period of seven years, according to Ctesias. (Herodotus, vi., 227.)

In the accompanying illustrations, taken from the excessively rare old work (C. Guichard, *Funérailles . . . .* Lyon, 1581) found in the Sainte Geneviève library, in Paris, is seen, at Fig. 1, one of the forms of structure erected for the rite of apotheosis. It shows the dead body of the king on the second tier, the procession of chariots around the structure, and the eagle taking its flight. In Fig. 2 is represented a different mode of structure, upon the reverse of a bronze medal of Severus. The other figures represent coins or medals of various rules showing the different forms in which the body was supposed to be taken heavenward. Fig. 3 is the reverse of a bronze medal of Antoninus Pius, where the eagle is seen grasping thunderbolts. Fig. 4 gives the obverse and the reverse of a silver coin of Valerius. Fig. 5 is the reverse of a medal of Mariniana, and Fig. 6 the reverse of a bronze medal of Faustina. In lieu of the design of an eagle, the last two bear that of a peacock, the favorite birds of Juno or Hera, employed only when the apotheosis was that of an empress. Upon the sides of a funeral altar in the Vatican can be seen the figures of G. Pomponius Edaémon and of his wife, Componia Helpis, carried to heaven respectively *by an eagle and by a peacock.*

In later days, several emperors had medals struck showing the body taken by the griffin of Apollo (god of light, god of the sun, son of Jupiter and of Latona) and holding some attribute of the gods—the scepter, thunderbolts, or the *Lasta pura.* The head of the emperor was sometimes made to bear a crown or it was surmounted by the nimbus, and the body occasionally rested upon a throne or solar quadriga, the latter being, by the way, admirably shown upon many of the coins and medals struck for the apotheosis of the much-esteemed emperor Flavius Valerius Constance Chlore, father of Constantine.

The eagle was e'er a royal bird, always employed as a symbol of force and of power. It might be added that throughout heraldry, it ranks as one of the most noble bearings in coat-armor.

By the Persians, the eagle was placed upon spears as standards, in the great battle of Cunaxa, Babylonia, B. C. 401, and it is said that the Romans adopted it for their legions during the second consulate of Marius, their greatest general. The first eagles were made of wood, wreaths were soon added, then these eagles were replaced by others made of silver with the bird resting upon golden thunderbolts, up to the period of the Cæsars, when the last-named gave way in turn to eagles made entirely of gold, and deservedly so, for as Tacitus said (Ann. II., 17), the eagles were by all considered the gods of the legions.

Charlemagne introduced the eagle to denote that he held government over both the Romans and the Germans, as shown upon the fine monument erected to him in the cathedral of Aix-la-Chapelle. As a sovereign emblem, the eagle held its own throughout the fifteenth century and prominently because the emblem of the Holy Roman Empire. The Napoleons also adopted it, placing it upon the flagstaffs first between the years 1804-1814, afterward between 1852 and 1870, in accordance with a design of Isabey borrowed from the eagles to be seen upon the tombs of the Viscontis. Some of these are in the Milan Cathedral, which latter, it may be added, was begun in 1386 with brick cased in marble taken from quarries which the Viscontis gave in perpetuity.

The eagle, be it said, is the fourth attribute of Christ, denoting especially his divinity and his glorious ascension.

In addition to the eagle upon funeral monuments, we again find the griffin (part lion, part eagle) as well as the serpent. An unusually fine and very large Greco-Roman sarcophagus, brought to France in 1844 from Salonica, representing an episode of the war between the Greeks and the Amazons, is in the Gallery Denon of the Louvre Museum, and on it can be seen thick wreaths held by an eagle and two griffins. A serpent with an eagle's head is found carved on one of the tombs of the Porta Capena, and is reproduced in Tavola XXIX. of the attractive work published thereon by C. L. Ghazzi. In the collection of antiquities belonging to the Bibliotheque Nationale, Paris, are many notable cameos representing the apotheosis, similar to those that are in the Vienna Museum, and one of these shows an emperor carried to heaven by an eagle, where he is about to be crowned anew with a wreath by an angel. A fine sardonyx in Vienna is said to represent the apotheosis of Augustus, which is likewise represented in an attractive *basso-relievo* in the chantry of the St. Vital Church in Ravenna. Still more interesting is the bronze disk in the Brussels Museum (Fig. 7), showing a serpent holding its tail and thus encircling the head of Jupiter, or more properly the head of Baal, the sun-god of the Syrians, Phœnicians, and heathen Hebrews, supported by a spread eagle whose wings appear as a luminous radiation.

The serpent, when found upon funeral monuments, is the symbol of renovation, resurrection, palingenesis. He was made to represent those who had been deified. From the highest antiquity he was classed among divine beings: he was considered the guardian of sanctuaries. In Egyptian mythology, he is likened unto the sun, i. e., life. Among the Hebrews, the same word, Héva, signifies life as well as serpent. Among the Greeks, the serpent biting its tail is the symbol of eternity, for the serpent represents life and the circle thus formed is without end.

It may be added that a very attractive emblem of eternity appears on many of the ancient monuments, and upon medals or coins of Vespasian, Titus, and others, in the form of a woman holding in her right hand a head surrounded by rays, to represent the sun, and in her left hand a head bearing a crescent, to represent the moon, such union of the two orbs of day and of night denoting the permanency of all time.

Weighing the Earth, Sun, and Planets

The Mighty Scales of Mathematics

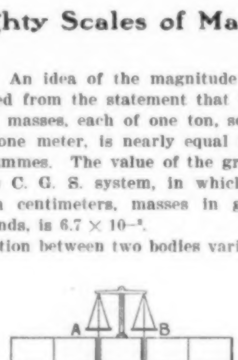
STRICTLY speaking, says a writer in Kosmos, the weight of an object is the force with which it is attracted by the earth. This force is inversely proportional to the square of the distance from the earth's center. Hence the weight of an object, as defined above and as measured with a spring balance, is less at the equator than at high latitude and less on a mountain top than at the sea level. The force of gravitation is proportional to the acceleration, or rate of change in velocity, of a body falling freely in a vacuum, and the varying weight of an object, as defined above, is the product of its mass by the gravitational acceleration at the place of observation. In the latitude of central Europe and the northern United States the velocity of fall *in vacuo* increases by about 32 feet, or 975 centimeters per second, in each second of falling. Hence the approximate numerical value of the gravitational acceleration (commonly denoted by the symbol g) is 32 in the English, and 975 in the metric system.

When an object is weighed on an ordinary balance with a set of standard "weights," however, the result does not differ at different places, because the object and the counterbalancing weights are equally affected by any variation in the force of gravity. The operation is, in fact, a measurement of the mass of the object in terms of standard masses, and this is what is commonly meant by weighing an object.

Although we cannot put the earth in a scale pan, we can weigh it with the aid of a balance.

Prof. Richarz filled a vault in the fortress of Spandan with 100 tons of lead, and placed above the vault a balance, from the pans of which two additional pans were suspended, beneath the mass of lead, by means of wires passing through vertical shafts which traversed the mass. He found that two one-kilogramme weights, which balanced when placed in the upper pans, or in the lower pans, did not balance when one was placed in an upper, and the other in a lower pan, although the additional weight required to restore the equilibrium was only about one milligramme. The discrepancy was due to the attraction exerted by the mass of lead, which pulled one of the kilogramme weights downward, and the other upward. From this experiment Richarz deduced the value of the "gravitation constant," which expresses the force of attraction between two unit masses at unit distance from each other. An idea of the magnitude of this force can be gained from the statement that the attraction between two masses, each of one ton, separated by a distance of one meter, is nearly equal to the *weight* of 7 milligrammes. The value of the gravitation constant in the C. G. S. system, in which lengths are expressed in centimeters, masses in grammes, and time in seconds, is 6.7×10^{-8}.

The attraction between two bodies varies directly as



WEIGHING THE EARTH WITH A BALANCE

the product of their masses, and inversely as the square of the distance between them. Hence the attraction between the earth and any object on its surface is $\frac{kMm}{\gamma^2}$, where k is the gravitation constant, M the mass of the earth, m the mass of the body, and γ the length of the earth's radius. This attraction is equal to the weight of the object, or mg, where g is the gravitational acceleration. Hence $\frac{kMm}{\gamma^2} = mg$, and therefore $M = \frac{gr^2}{k}$.

Substituting for g and k the values already given, and for γ the length of the earth's radius in centimeters, we find the mass of the earth, M, equal to 68×10^{26} grammes, or 68×10^{20} metric tons.

The volume of the earth, calculated from its known dimensions, is 12×10^{20} cubic meters. Hence the density of the earth is about 5½ times that of water, as a metric ton is the mass of a cubic meter of water.

The mass of the sun is deduced from the attraction which it exerts upon the earth. This attraction may also be expressed by the formula $\frac{kMm}{\gamma^2}$, but M now denotes the mass of the sun, m the mass of the earth, and γ the distance between the sun and the earth. This attraction, however, is the centripetal force which holds the earth in its orbit, and which is expressed by the formula $\frac{mv^2}{\gamma}$, in which v denotes the linear velocity of the earth in its orbit. Hence $\frac{kMm}{\gamma^2} = \frac{mv^2}{\gamma}$ and therefore $M = \frac{v^2r}{k}$. Substituting the values of v, γ, and k, we find $M = 2 \times 10^{33}$ grammes or 2×10^{27} metric tons.

The mass of the sun, as thus determined, is 325,000 times that of the earth. The sun's diameter is more than 100 times, and its volume is nearly 1,250,000 times, that of the earth. Hence the sun is about four times less dense than the earth, or not very much denser than water.

The mass of any planet which has a satellite can be deduced from the distance and orbital velocity of the satellite, as the mass of the sun is deduced from the distance and velocity of the earth. The mass of a planet which has no satellite is obtained, less simply, from the perturbations which it causes in the motions of other planets. If the earth's mass is taken as unity, the masses of the other planets are: Mercury 1/16, Venus ⅘, Mars 1/9, Jupiter 300, Saturn 90, Uranus 13, and Neptune 16. The earth is denser than any other planet except Mercury. The density of Saturn is less than that of water.

The masses of the fixed stars can only be guessed from their relative brightness and distance and from the periods of rotation of some lunary systems, such as that of Algol in the constellation Perseus.

Exact measurements are out of the question.

INDEX OF INVENTIONS

For which Letters Patent of the United States were Issued for the Week Ending January 17, 1911,

AND EACH BEARING THAT DATE

[See note at end of list about copies of these patents.]

Acid, production of compounds of persulfuric, G. Teichner 981,900
Acoustic diaphragms, making, W. W. Young 982,027
Adding machine for cash registers, etc., F. L. Fuller 981,633
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Relasting machine, J. C. Schelter 981,800
Rim, demountable, A. R. Behnke 981,740
Rivet, O. Link 982,078
Roadways, railway beds, pavements, etc., making, M. A. Popkess 981,685
Roofing compound, J. T. Conse 981,916
Ropes, means for joining the ends of driving and other, Shufflebottom & Kenworthy 981,802
Rotary engine, R. F. C. Keats 981,862
Rotary engine, C. E. Clapp 982,035
Rotary engine, E. Hager 982,054
Rotor, manually operated high speed, M. Goehler 981,757
Roundabout, observation, V. H. Davison 982,128
Rowboat, L. M. Doan 982,202
Saddle, C. A. Persons 981,939
Sash balance, Gambill & Woods 982,048
Sash fastening device, storm, J. F. Adams 982,169
Sash, metallic window, W. F. Bonness 981,972
Saw handle, A. R. Hutkin 982,003
Sawdust box, F. P. Boland 981,911
Sawmills, dog attachment for, C. L. Robbins 981,945
Scaffold, portable, A. H. McGhan 982,083
Seal, E. J. Brooks 982,122
Seal, car, E. J. Brooks 982,121
Sealed can, wax, O. J. Johnson 982,070
Seeding machine, S. Sorensen 981,704
Separators, blue milk outlet in centrifugal, A. L. Christenson 982,200
Sewing machine, two-reel, D. Flanagan 981,629
Sewing machines, feeding mechanism for blindstitch, L. Onderdonk 982,219
Shaft coupling, flexible, J. A. White 981,964
Shafts, flexible joint for, A. E. Zock 981,736
Ship cleaner, electrolytic, G. W. Frasier 981,922
Shock absorber, W. B. Knapp 982,008
Shoe, snow, J. C. Haefer 982,053
Skylight, B. Storch 981,815
Smelting process and apparatus therefor, R. Fleming 981,850
Snap contact, R. W. Magna 981,933
Snap switch, J. A. York 981,734
Soap, manufacture of resin, F. S. Havens 981,947
Solenoid operated switch, H. L. Smith 982,100
Sowing Paris green, machine for, T. J. Churchill 981,614
Spark plug, W. Falwell 981,993
Spectacles, J. H. Monroe 981,872
Speed indicator and recorder, A. D. Renfro 982,021
Speed mechanism, differential, H. A. Rhodes 981,689
Speed transmission device, variable, J. B. Runner 981,797
Spoke tenoning machine, E. E. Fletcher 981,990
Sprayer, liquid, J. E. Thornycroft 982,106
Spring construction, L. A. Young 981,735
Spring wheel, C. M. Backman 981,831
Sputum cup, C. L. Knudsen 982,211
Square, T. W. McCormick 981,867
Stairways, runway for, E. V. Carter 982,013
Stamp, time, C. S. Ellis 981,627
Stand. See Switch stand.
Starting device, C. E. Carpenter 981,612
Steam generator, J. Van Oosterwyck 981,722
Steering apparatus, P. Lord 982,215
Stock tank and heater, automatic, U. G. Smith 982,101
Stove lids, mold pattern for, W. H. Tapborn 981,898
Stove, portable, G. Beyer 981,998
Strainer, G. Smith 981,805
Street cleaning machine, J. B. D'Homergue 981,652
Street cleaning pan, Rolfe & Baker 981,883
Stud, collar, G. S. Butterfield 982,124
Suspender cast off, Oppenheim & Cleary 981,676
Switch operating device, H. F. Scatchard 981,886
Switch operating means, electric, T. Pinckney 981,683
Switch stand, W. F. Traves 981,721
Switches, control of electrically operated, E. B. Carichoff 982,032
Switches, emergency operating means for reversing, F. E. Case 982,033
Switching device, F. W. Harris 981,759

Electrical Notes

Large electromagnets have been employed by oculists, for more than twelve years, for the removal of splinters of iron and other magnetic metals that have entered the eye. Two French surgeons regularly and successfully employ a very powerful electromagnet for the extraction of needles and similar foreign bodies from the tissues in general. The needle—it is usually a needle—is first located very accurately by means of two X-ray radiographs, taken in different planes. The electromagnet being then applied to the skin, in the most favorable position, draws the needle to the spot and causes it either to emerge through the skin or to produce a little conical elevation of the skin. In the latter case it is necessary to make an incision less than half an inch in length in order to allow the needle to escape from the skin.

Prof. Lippmann of Paris has been making researches upon electric contacts and finds that he can produce a contact without using pressure. This may prove of great service for relay work, as the problem in making a sensitive relay consists in securing enough pressure to make the contact. It is known that when two metal pieces are in contact, a certain pressure is needed in order to make the current pass, even when gold or platinum is used. This causes the difficulty in making a relay to work on very small currents, as we cannot have sufficient contact without much difficulty. Prof. Lippmann sought to obtain a contact which would work without any pressure, and succeeded by using a metal on one side and an electrolyte on the other. A chloride of calcium solution answers very well, and he uses a strip of letter paper wet with the solution and applied against a glass strip which serves as a support, immersing the lower end in a vessel containing the liquid so that part of the paper projects above. The solution serves to keep up the moisture and it also brings the current to the paper. He finds that the slightest contact between the paper and a metal piece is enough to make an electric contact. This is proved by taking a gold leaf piece for the metal part. A galvanometer or relay in the circuit always works in this case, and as the gold leaf is too flexible to give any appreciable pressure, the result is striking. Should a large surface of metal be used, such a contact would stick and require some force to separate it. In some cases this would not be a disadvantage, but in others the contact surface should be small. As to the use of mercury, it is known that a wire must be dipped well into the mercury in order to make an electric contact. However, two amalgamated silver wires will make contact without pressure on the above principle, provided the surface is kept wet with mercury.

According to a note in *The Electrician*, a standard gage light railway at Gummersbach has recently been electrified. The railway is intended principally for goods and carrying ore, but there will also be a few passenger trains. High-tension three-phase current at a pressure of 10,000 volts and a frequency of 50 will be obtained from the local electricity works and transformed by two 150-kilowatt motor generators to continuous current at 750 volts for supply to the trolley wire. The railway is ten miles long, the maximum distance from the transformer station being five miles. The goods consist for the most part of stone from the stone quarries, which is only carried in one direction, so that only fairly empty wagons have to be drawn against the gradient. Owing to this circumstance the average consumption on the continuous-current side is only 160 watt-hours per ton-mile. The goods trains, which consist of six standard open wagons, are drawn by locomotives weighing 20 tons and fitted with two 60-horse-power motors, without causing any great variation of load at the transformer station. A comparison between the two systems of working—steam and electricity—shows that the latter is more efficient.

Trade Notes and Formulæ

The following recipes and formulæ are published simply as suggestions. Chemicals vary, for which reason it is not always possible to comply with the conditions stated, or for us to guarantee the accuracy of the recipes. A little experimenting, however, will easily enable the interested reader to ascertain just what modifications are necessary to meet his requirements.—Editor of Scientific American Supplement.

Weather-Foretelling Pictures.—Production: 1 part chloride of cobalt, 10 parts gelatine, 100 parts water, which gives blue color; 1 part chloride of copper, 10 parts gelatine, 10 parts water, for yellow; 1 part chloride of cobalt, 0.75 part nitrate of nickel, 0.25 part chloride of copper, 20 parts gelatine, and 200 parts water, gives green. Soften the gelatine in water, add the preparations and melt over a gentle fire.

To Mark Tools.—Coat the tools to be marked with a thin covering of wax or hard tallow by heating the steel, rubbing the wax over it while warm until it melts and then allowing it to cool. Now scratch the mark in it with a sharp instrument and pour on nitric acid, rinsing the acid off with water, after a time; finally heat the metal until the wax melts and wipe it off. The mark appears as though engraved.

Manifolding Drawings and Documents (according to Alfred Astfalck).—A sheet of paper, blackened with iron gall-nut ink and moistened with sulphate of ammonia, is covered with another sheet, on which is written or drawn with ink that is a non-conductor of electricity. Both sheets, between conductive plates, are exposed to an electrical or galvanic current and the first sheet is then washed with water. The effect is produced by the electrolytic decomposition of the ink.

To Transfer and Fix Drawings on Ivory and Vegetable Ivory.—The picture to be transferred is printed as a negative, by lithographic process, in a black fatty ink on a paper prepared for transferring in the well-known manner. By transfer printing, the picture is placed on the article to be decorated. The latter is rinsed in clean water and finally, light being excluded, is passed through a solution of nitrate of silver, then exposed to the effects of daylight. The parts free from fatty color are thereby tinted dark; the black color is washed off with exclusion of light in rectified oil of turpentine and the object immersed in a solution of hyposulphite of soda. Various colors may be obtained by the use of different substances sensitive to light, and by the use of baths of varying strength.

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